Lysack W. 1981.

1980 Lake Winnipeg Fish Stock Assessment Program

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ABSTRACT

This report presents the results of the 1980 Lake Winnipeg fish stock assessment program. Maturity rates of northern and southern walleye and sauger females were not significantly different but southern female walleyes and saugers began maturation significantly earlier than their northern counterparts. Mean ages of maturity of walleyes and saugers were at least 2 years younger in the south basin than in the north basin. The maturity rate and mean age of maturity of the northern whitefish stock has not changed significantly since 1979.

Asymptotic sizes of walleyes and saugers generally decreased from the north end to the south end of Lake Winnipeg. Walleyes and saugers grew faster in the south basin than in the north basin. Whitefish growth rates have not changed significantly since 1979.

Mortality rates and catch curves of northern whitefish have remained essentially static since 1979. Mortality rates of northern walleye and sauger stocks have increased since 1979.

The appearance of weak cohorts in southern walleye age compositions in 1980 is attributed to increased ageing precision. Southern Lake Winnipeg fishermen are relying on fewer cohorts composed of younger, immature fish. Use of smaller meshes and

greater fishing effort on southern Lake Winnipeg is forcing saugers and walleyes to grow and mature at extremely high rates. The resiliency of the southern walleye stock is deteriorating. Northern walleye stocks are beginning to show compensatory increases in growth and maturity in response to heavier fishing pressure.

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INTRODUCTION

This report presents the results of the second annual fish stock assessment program on Lake Winnipeg. This program was initiated in response to a need for a standardized stock monitoring program so that year-to-year comparisons of population dynamics would be valid (Lysack 1980).

The objectives of this study were to:

1. estimate mortality rates
2. describe maturity regimes
3. describe growth regimes
4. compare mean biomasses of fish species caught in various meshes in the north basin, channel and south basin of Lake Winnipeg.
5. determine age compositions, mean ages and mortality rates of commercially caught walleyes, saugers and whitefish
6. relate population characteristics to commercial fishing activities in the north basin, channel and south basin of Lake Winnipeg.

This study was restricted to the ice-free season on Lake Winnipeg. Only one or two gangs of gillnets were set once at each sampling site.

METHODS AND MATERIALS

The methods employed in this study were identical to those described by Lysack (1980) with the following exceptions:

1. the 1980 sampling period (early June to mid-July) was earlier than it was in 1979.
2. twelve gangs were set in the north basin, four gangs were set in the channel and eighteen gangs were set in the south basin (Fig. 1).
3. the "developing" category was eliminated from the maturity classifications.
4. A spring scale with an improved accuracy ($\pm$ 5 gm) was used to weigh each fish.
5. Frequencies of mature walleyes, saugers and whitefish at various ages were transformed as follows:

$$-\log_e \left(\frac{k - y}{y}\right) = -bX_o + bX$$

where k = frequency of mature fish among the oldest age groups

X_o = age at inflection

b = slope

x = age

Mortality rates were calculated according to Robson and Chapman (1961) and by least squares regression of the descending limbs of catch curves. Routine statistical analyses were performed according to Snedecor and Cochran (1967).

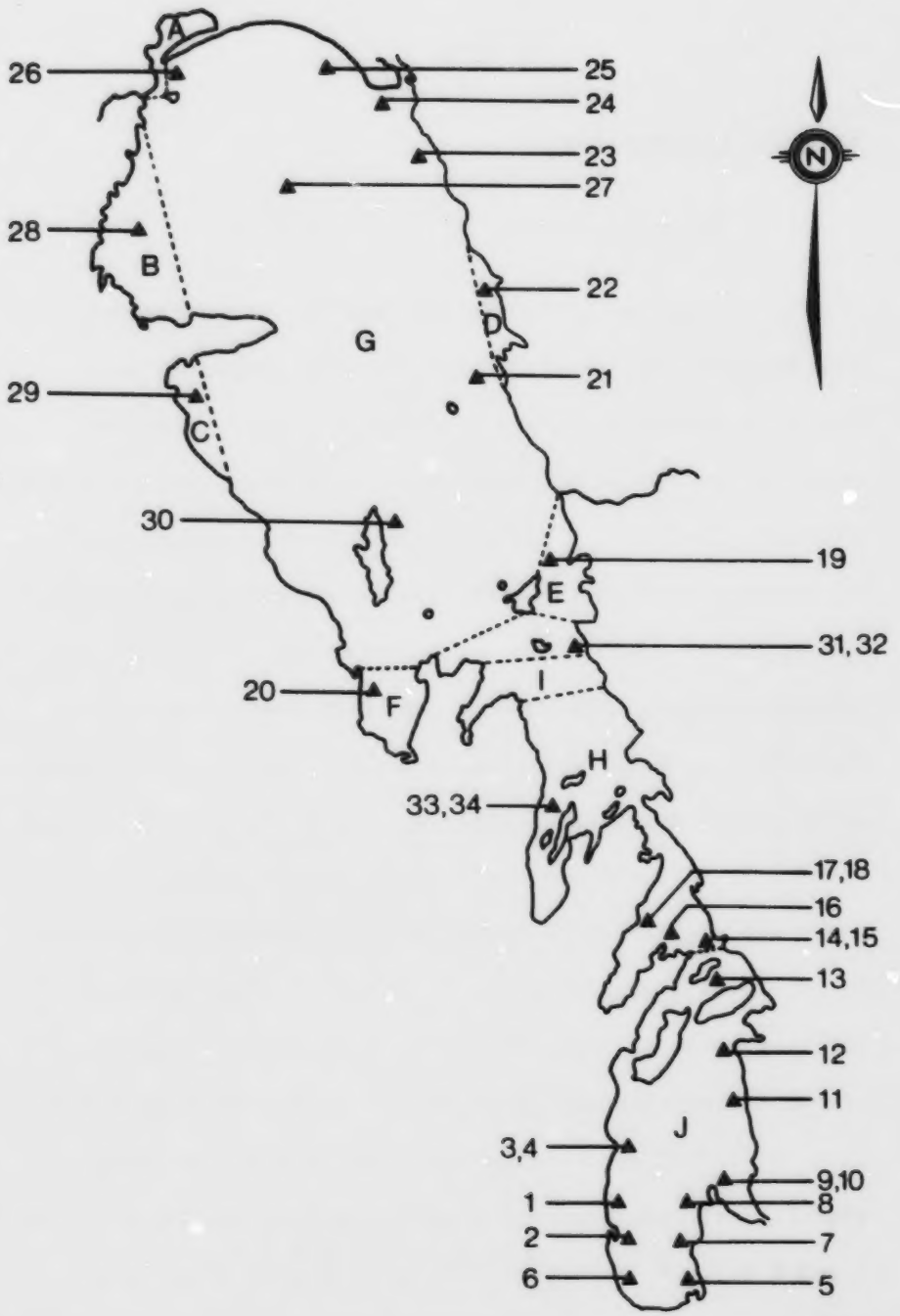

Fig. 1. Locations of sampling stations on Lake Winnipeg. Numbers indicate chronological order of gang sets. Areas A - F are management areas of the summer fishery.

RESULTS

Experimental sampling

Maturity regimes

Analyses of female and combined sexes maturity schedules of saugers (Table 1), walleyes (Table 2) and whitefish (Table 3) showed significant relationships of maturity and age in all cases except northern combined sexes walleyes (Table 4). Female walleyes matured faster in the north basin than in the south basin. Female saugers matured slowly in the north basin, at an intermediate rate in the channel and at a high rate in the south basin (Table 4). Instantaneous maturity rates of northern and southern female saugers were not significantly different ($F = 1.381$, 1 and 6 d.f., $P = 0.05$) but the southern female sauger maturity curve was significantly higher than its northern counterpart ($F = 21.645$, 1 and 7 d.f., $P = 0.05$). Instantaneous maturity rates of northern and southern female walleyes were not significantly different ($F = 0.374$, 1 and 5 d.f., $P = 0.05$) but southern walleye females begin maturing significantly earlier than northern walleye females ($F = 11.603$, 1 and 6 d.f., $P = 0.05$). The mean ages of maturity of walleyes and saugers (interpolated from the maturity curve and estimated according to the corrected Abrasov (1967) formula (Lysack 1980)) were higher in the north basin than they were in the south basin. Abrasov's mean age of maturity was consistently higher than the mean age of maturity interpolated from the maturity curve (Table 4). The female: male sex ratio of saugers

Table 1. Maturity schedules of northern, channel and southern stocks.

Area	Age (years)	No. immature			No. mature			% mature		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
North	1									
	2	0	1	1	0	0	0	0	0	0
	3	1	2	3	0	0	0	0	0	0
	4	2	8	10	6	1	7	75.00	11.11	41.18
	5	19	19	38	17	29	46	47.22	60.42	54.76
	6	10	35	45	46	92	138	82.14	72.44	75.41
	7	6	24	30	68	111	179	91.89	82.22	85.65
	8	3	8	11	66	124	190	95.65	93.94	94.53
	9	2	1	3	46	62	108	95.83	98.41	97.30
	10	3	0	3	27	33	60	90.00	100.00	95.24
	11				8	12	20	100.00		100.00
	12				4	5	9			
	13				2	1	3			
	14				0	1	1			
					sex ratio = 1.693 female: 1 male					
Channel	1	1	0	1	0	0	0	0	0	0
	2	2	2	4	0	0	0	0	0	0
	3	9	8	17	2	0	2	18.18	0	10.53
	4	40	34	74	15	5	20	27.27	12.82	21.28
	5	38	24	62	42	20	62	52.50	45.45	50.00
	6	15	5	20	27	23	50	64.29	82.14	71.43
	7	3	2	5	18	9	27	85.71	81.82	84.38
	8	1	0	1	2	1	3	66.67	100.00	75.00
	9				0	1	1			
	10				0	0	0			
	11				1	0	1			
					sex ratio = 0.620 female: 1 male					
South	2	0	2	2	0	0	0	0	0	0
	3	3	1	4	1	0	1	25.00	0	20.00
	4	5	3	8	29	10	39	85.29	76.92	82.98
	5	9	10	19	81	39	120	90.00	79.59	86.33
	6	1	2	3	85	62	147	98.84	96.88	98.00
	7	0	0	0	30	38	68	100.00	100.00	100.00
	8	0	1	1	10	16	26	100.00	94.12	96.30
	9	0	0	0	4	3	7	100.00	100.00	100.00
	10	0	0	0	0	2	2			
					sex ratio = 0.733 female: 1 male					

Table 2. Maturity schedules of northern and southern walleye stocks.

Area	Age (years)	No. immature			No. mature			% mature		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
South	0									
	1									
	2	1	1	2	0	0	0	0	0	0
	3	1	19	20	0	1	1	0	5.00	4.76
	4	15	68	83	11	24	35	42.31	26.09	29.66
	5	6	13	19	14	10	24	70.00	43.48	55.81
	6	7	17	24	22	27	49	75.86	61.36	67.12
	7	1	0	1	2	18	20	66.67	100.00	95.24
	8				3	30	33	100.00	100.00	100.00
	9				0	2	2			
					sex ratio = 2.77 female: 1 male					
North	3	2	0	2	0	0	0	0	0	0
	4	5	12	17	0	0	0	0	0	0
	5	10	42	52	0	4	4	0	8.70	7.14
	6	29	75	104	5	3	8	14.71	3.85	7.14
	7	9	34	43	12	4	16	57.14	10.53	27.12
	8	1	7	8	11	15	26	91.67	68.18	76.47
	9	0	0	0	1	2	3	100.00	100.00	100.00
	10	0	0	0	2	0	2			
					sex ratio = 2.28 female: 1 male					

Table 3. Whitefish maturity schedules.

Area	Age (years)	No. immature			No. mature			% mature		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
North	2	3	3	6	0	0	0	0	0	0
	3	59	79	138	1	1	2	1.67	1.25	1.43
	4	121	102	223	4	19	23	3.20	15.70	9.35
	5	244	159	403	61	147	208	20.00	48.04	34.04
	6	211	107	318	131	244	375	38.30	69.52	54.11
	7	57	35	92	61	111	172	51.69	76.03	65.15
	8	19	7	26	17	39	56	47.22	84.78	68.29
	9	2	1	3	9	21	30	81.82	95.45	90.91
	10	1	1	2	4	7	11	80.00	87.5	84.62
	11				1	1	2	100.00	100.00	100.00

sex ratio = 1.078 female: 1 male

Table 4. 1980 maturity curves of Lake Winnipeg walleyes, saugers and whitefish.

Species	Area	Type	Maturity curve $-\log_e(\frac{k-y}{y}) = a + b \cdot age$	Correlation coefficient	Age at 50% mature (years)	Abrasov's mean age of maturity (years)	Test F value and d.f.
Walleye	North	female	Y = -11.000 + 1.457X +	0.895	7.55	8.04	12.07(1,3)
		all fish	Y = - 9.561 + 1.281X	0.933	7.464	7.82	13.42(1,2)
	South	female	Y = -5.896 + 1.100X	0.968	5.36	5.41	29.92(1,2)
		all fish	Y = - 6.764 + 1.356X	0.977	4.99	5.57	63.44(1,3)
Sauger	North	female	Y = - 5.874 + 1.101X	0.973	5.34	6.87	71.33(1,4)
		all fish	Y = - 3.735 + 0.810X	0.997	4.61	5.462	670.92(1,4)
	Channel	female	Y = - 6.071 + 1.141X	0.965	5.32	6.47	41.20(1,3)
		all fish	Y = - 5.108 + 0.988X	0.996	5.17	5.48	388.38(1,3)
	South	female	Y = - 5.427 + 1.462*	0.956	3.712	5.90	21.11(1,2)
		all fish	Y = - 5.759 + 1.609X	0.956	3.58	5.53	21.13(1,2)
Whitefish	North	female	Y = - 6.399 + 1.081X	0.952	5.92	6.30	48.70(1,5)
		all fish	Y = - 6.252 + 0.963X	0.959	6.49	6.92	56.90(1,5)

* Inclusion of X = 3 Y = 20% increased r from 0.803 to 0.956
\+ Inclusion of X = 9, Y = 95% increased r from 0.777 to 0.895

was much greater in the north basin than in the channel and south basin (Table 1). The female: male sex ratio of walleyes showed female dominance in both the north and south basins (Table 2).

Growth regimes

Age-specific mean lengths and weights of saugers(Table 5), walleyes (Table 6) and whitefish (Table 7) from the three major areas of Lake Winnipeg were used to derive length-weight relationships (Table 8). Covariance analysis of log transformed sauger length-weight curves showed no significant differences between the slopes of the northern and southern curves ($F = 3.94$, 1 and 21 d.f., $P = 0.05$) but the northern sauger curve was significantly higher than its southern counterpart ($F = 6.89$, 1 and 22 d.f., $P = 0.05$). Saugers from all three areas of the lake grew proportionately heavier with increasing length. No significant differences between slopes or elevations occurred between the length-weight curves of walleyes from the northern and southern basin (slopes $F = 0.038$, 1 and 12 d.f., $P = 0.05$, elevations $F = 1.349$, 1 and 13 d.f., $P = 0.05$). Walleye growth in both basins was negatively allometric. The slopes and elevations of northern and channel whitefish length-weight curves were significantly different (slopes $F = 11.76$, 1 and 12 d.f., $P = 0.05$, elevations $F = 55.38$, 1 and 13 d.f., $P = 0.05$). Channel whitefish growth was negatively allometric while northern whitefish growth was positively allometric.

Table 5. Age-specific mean fork lengths and weights of saugers from the three major areas of Lake Winnipeg, 1980.

Age (years)	Area														
	South end					Channel					North end				
	No.fish	Mean length (mm)	1S.E.	Mean weight (gm)	1S.E.	No.fish	Mean length (mm)	1S.E.	Mean weight (gm)	1S.E.	No.fish	Mean length (mm)	1S.E.	Mean weight (gm)	1S.E.
0	1	92.00	-	5.00	-										
1	2	165.00	3.00	42.00	7.50	12	153.50	9.07	35.83	4.52	2	155.00	19.00	50.00	30.00
2	2	187.00	17.00	80.00	20.00	23	179.65	3.70	50.87	3.82	2	193.00	9.00	70.00	10.00
3	5	262.80	7.86	179.00	16.16	19	239.37	4.37	133.16	7.30	4	198.00	15.58	85.00	18.48
4	49	276.57	6.35	225.00	15.06	94	266.15	2.05	185.43	4.02	19	263.16	4.70	198.95	12.79
5	143	298.31	1.73	267.35	5.35	125	280.03	1.96	218.96	4.71	84	290.76	3.39	262.38	7.70
6	152	308.88	2.29	302.24	5.89	70	297.17	2.77	264.00	8.51	183	320.67	2.18	360.74	7.68
7	68	320.75	3.48	334.65	9.77	32	311.00	4.88	308.75	15.40	209	336.58	1.90	424.78	7.67
8	27	331.93	5.12	369.81	18.94	4	323.50	14.50	352.50	52.97	201	352.17	1.93	506.02	8.58
9	7	322.57	12.23	329.29	39.89	1	422.00	-	710.00	-	111	369.30	2.62	579.82	13.11
10	2	359.50	9.50	470.00	30.00	1	396.00	-	630.00	-	63	386.97	3.53	697.46	22.41
11											20	409.40	6.39	807.00	45.02
12											9	410.44	6.97	842.22	45.51
13											3	435.33	28.67	943.33	137.76
14											1	460.00	-	1150.00	-

Table 6. Age-specific mean fork lengths and mean weights of walleyes from the northern and southern basins of Lake Winnipeg, 1980.

Age (years)	Area									
	South end					North end				
	No. fish	Mean length (mm)	1S.E.	Mean weight (gm)	1S.E.	No. fish	Mean length (mm)	1S.E.	Mean weight (gm)	1S.E.
0	1	88.00	-	10.00	-					
1	0					1	126.00	-	30.00	-
2	2	229.00	9.00	125.00	15.00					
3	24	317.29	8.10	360.21	20.11	4	204.50	24.92	95.00	39.69
4	158	365.57	2.27	548.65	10.02	17	330.71	9.99	425.88	31.37
5	50	384.20	5.13	654.40	29.56	57	361.81	5.82	534.04	24.83
6	83	402.10	5.54	755.72	34.84	112	382.40	2.65	652.32	14.73
7	22	452.73	11.03	1033.18	68.66	59	403.92	4.09	764.41	23.91
8	33	459.12	7.21	1118.79	53.69	34	441.24	6.96	1017.06	51.63
9	2	414.00	42.00	720.00	220.00	3	442.67	46.99	1160.00	180.09
10						2	389.00	7.00	705.00	55.00

Table 7. Age-specific mean fork lengths and mean weights of whitefish from the north basin and channel of Lake Winnipeg.

Age (years)	Area									
	North Basin					Channel				
	No. fish	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	No. fish	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.
2	6	247.33	8.65	213.33	24.86	8	305.25	16.38	481.25	85.28
3	140	299.36	2.44	366.00	8.98	25	329.68	6.14	600.40	31.25
4	246	337.99	1.52	508.57	8.62	64	354.94	3.62	747.34	21.31
5	612	372.54	1.05	784.84	7.68	65	374.89	3.25	893.85	26.40
6	693	392.27	0.88	926.96	8.38	24	389.17	4.48	987.92	39.44
7	264	406.11	1.47	1034.39	14.42	8	407.50	12.21	1098.75	90.42
8	82	417.79	3.60	1124.88	35.04					
9	33	439.97	5.72	1336.36	52.78					
10	13	458.46	13.35	1555.38	150.25					
11	2	496.00	24.00	1940.00	170.00					

Table 8. Age-specific length-weight relationships of saugers, walleyes and whitefish from the three major areas of Lake Winnipeg.

Species	Area	Length-weight equation $\log_e$ weight = a + b $\log_e$ length	Correlation coefficient	Test F ratio and d.f.
Sauger	North	$\log_e Y = -11.559 + 3.031 \log_e X$	0.997	2303.60 (1,12)
	Channel	$\log_e Y = -11.881 + 3.063 \log_e X$	0.999	3766.73 (1, 8)
	South	$\log_e Y = -12.924 + 3.252 \log_e X$	0.996	1191.75 (1, 9)
Walleye	North	$\log_e Y = -10.651 + 2.884 \log_e X$	0.998	1536.47 (1, 7)
	South	$\log_e Y = -10.587 + 2.865 \log_e X$*	0.999	3279.24 (1, 6)
Whitefish	North	$\log_e Y = -12.441 + 3.226 \log_e X$	0.999	7786.35 (1, 8)
	Channel	$\log_e Y = -10.494 + 2.914 \log_e X$	0.999	2488.77 (1, 4)

* size of 9 year old walleyes deleted from analysis.

Walford plots for saugers, walleyes and whitefish from the three major areas of Lake Winnipeg showed significant relationships of L_{t+1} and L_t in all cases (Table 9). The asymptotic size of saugers was highest in the north basin, intermediate in the channel and lowest in the south basin. Asymptotic sizes of walleyes and whitefish were highest in the northern basin (Table 9).

To determine growth rates, untransformed age-specific lengths were transformed according to exponential and von Bertalanffy growth models (Table 10). Correlation coefficients of regressions of $\log_e (L_\infty - 1_t)$ on t (Table 11) were considered representative of the von Bertalanffy growth curve since these regressions provided estimates of parameters comprising the von Bertalanffy equation. The von Bertalanffy transformation produced the highest correlation coefficients in most cases (Table 10). Von Bertalanffy growth curves of saugers indicate that growth rates increase and asymptotic sizes decrease from the north to the south end of Lake Winnipeg (Table 12). When exponential growth curves include only younger saugers, growth rates increase from the north to the south end of the lake. This trend is reversed when exponential growth curves include all saugers (Table 12). Von Bertalanffy growth curves of walleyes indicate that growth rates increase and asymptotic sizes decrease from the north end to the south end of Lake Winnipeg. Exponential growth rates of northern and southern walleyes were not significantly different during the first five years ($F = .0047$, 1 and 5 d.f., $P = 0.05$) but the southern walleye exponential growth curve was significantly higher than its northern counterpart ($F = 6.60$, 1 and 6 d.f., $P = 0.05$).

Table 9. Linear equations of Walford plots fitted by regression.

Species	Area	Walford equation $L_{t+1} = a + bL_t$	L_∞ (mm)	Correlation coefficient	Test F ratio and d.f.
Sauger	North	$Y = 57.124 + 0.886X$[a]	500	0.982	246.21 (1,9)
		$Y = 100.075 + 0.765X$[b]	425	0.987	254.69 (1,7)
	Channel	$Y = 73.771 + 0.799X$[c]	367	0.972	84.29 (1,5)
	South	$Y = 98.822 + 0.706X$[d]	334	0.964	91.81 (1,7)
Walleye	North	$Y = 215.954 + 0.502X$[e]	433	0.930	25.62 (1,4)
		$Y = 95.007 + 0.811X$[f]	500	0.951	28.13 (1,3)
	South	$Y = 158.221 + 0.666X$	473	0.957	43.44 (1,4)
Whitefish	North	$Y = 76.531 + 0.869X$	585	0.986	247.17 (1,7)
	Channel	$Y = 59.798 + 0.888X$	530	0.997	451.74 (1,3)

a. including all age-specific lengths
b. deleting mean lengths at ages 1 and 2
c. deleting mean lengths at ages 8-10
d. deleting mean length at age 10
e. deleting mean lengths at ages 9-10
f. deleting mean lengths at ages 3, 9, 10

Table 10. Correlation coefficients of untransformed and transformed growth curves.

Species	Area	Transformation		
		Untransformed	Exponential	Von Bertalanffy
Sauger	North	0.981	0.976-0.989	0.973-0.994
	Channel	0.967	0.976-0.987	0.994
	South	0.914	0.973-0.978	0.986
Walleye	North	0.917	0.927-0.930	0.970
	South	0.880	0.977	0.963
Whitefish	North	0.978	0.993	0.982
	Channel	0.995	0.998	0.999

Table 11. Relationships of $\log_e (L_\infty - l_t)$ and t for saugers, walleyes and whitefish from the three major areas of Lake Winnipeg.

Species	Area	$\log_e (L_\infty - l_t) = a - bt$	Correlation coefficient	Test F ratio and d.f.
Sauger	North	$\log_e (500 - l_t) = 6.091 - 0.147t$ [a.]	-0.980	297.84(1,12)
		$\log_e (500 - l_t) = 6.026 - 0.134t$ [b.]	-0.994	896.64(1,11)
		$\log_e (425 - l_t) = 6.440 - 0.300t$ [a.]	-0.973	141.87(1, 8)
		$\log_e (425 - l_t) = 6.096 - 0.236t$ [c.]	-0.994	527.35(1, 6)
	Channel	$\log_e (367 - l_t) = 5.596 - 0.228t$ [d.]	-0.994	389.57(1, 5)
	South	$\log_e (334 - l_t) = 5.564 - 0.382t$ [e.]	-0.986	242.37(1, 7)
Walleye	North	$\log_e (500 - l_t) = 6.181 - 0.248t$ [f.]	-0.970	47.70(1, 3)
	South	$\log_e (473 - l_t) = 6.578 - 0.471t$ [g.]	-0.963	64.57(1, 5)
Whitefish	North	$\log_e (585 - l_t) = 6.055 - 0.128t$	-0.982	220.82(1, 8)
	Channel	$\log_e (530 - l_t) = 5.655 - 0.120t$	-0.999	2384.38(1, 4)

a. using all mean lengths

b. deleting mean length at age 14

c. deleting mean lengths at ages 11-14

d. deleting mean lengths at ages 8-10

e. deleting mean length at age 8

f. deleting mean lengths at age 3, 9+

g. deleting mean lengths at ages 0, 9+

Table 12. Exponential and von Bertalanffy growth curves of saugers, walleyes and whitefish from the three major areas of Lake Winnipeg.

Species	Area	Growth curves		
		Exponential		von Bertalanffy
		$\log_e$ length = a + b · $\log_e$ age	Age range (years)	$length_t = L_\infty (1 - e^{-k(t - t_o)})$
Sauger	North	log Y = 4.971 + 0.429logX	1-14	$l_t = 500 (1 - e^{-0.147 (t + 0.841)})$
		log Y = 4.980 + 0.420logX	1- 8	$l_t = 425 (1 - e^{-0.236 (t - 0.186)})$
	Channel	log Y = 4.978 + 0.422logX	1-10	$l_t = 367 (1 - e^{-0.228 (t + 1.357)})$
		log Y = 5.015 + 0.379logX	1- 8	
	South	log Y = 4.976 + 0.415logX	0-10	$l_t = 334 (1 - e^{-0.382 (t + 0.647)})$
		log Y = 4.958 + 0.472logX	0- 7	
Walleye	North	log Y = 4.809 + 0.628logX	1- 8	$l_t = 500 (1 - e^{-0.248 (t + 0.136)})$
	South	log Y = 4.976 + 0.601logX	0- 8	$l_t = 473 (1 - e^{-0.471 (t - 0.889)})$
Whitefish	North	log Y = 5.290 + 0.369logX	2-10	$l_t = 585 (1 - e^{-0.128 (t + 2.474)})$
	Channel	log Y = 5.553 + 0.231logX	2- 7	$l_t = 530 (1 - e^{-0.120 (t + 5.149)})$

Age compositions, catch curves and mortality rates

The age composition of northern saugers was relatively more platykurtic than that of channel and southern saugers (Fig. 2). The mean weighted age of northern saugers, 7.35 years, was higher than the mean ages of channel saugers, 4.76 years, and southern saugers, 5.68 years. Relatively more younger saugers (0-4 years old) were recruited to the experimental gang in the south basin and channel than in the north basin (Fig 2).

The age composition of northern walleyes was dominated by six year old fish while four year old walleyes were dominant in the south basin (Fig. 3). The southern walleye age composition was abnormal and showed relatively weak contributions of five and seven year old fish. The mean weighted age of the northern walleye stock, 6.12 years,was 1.07 years older than the mean weighted age of the southern walleye stock, 5.05 years.

The northern whitefish age composition was dominated by five and six year old fish while the channel whitefish age composition was dominated by four and five year old whitefish. Substantially more two, three and four year old whitefish were netted in the channel area than in the north basin (Fig. 4). The mean weighted

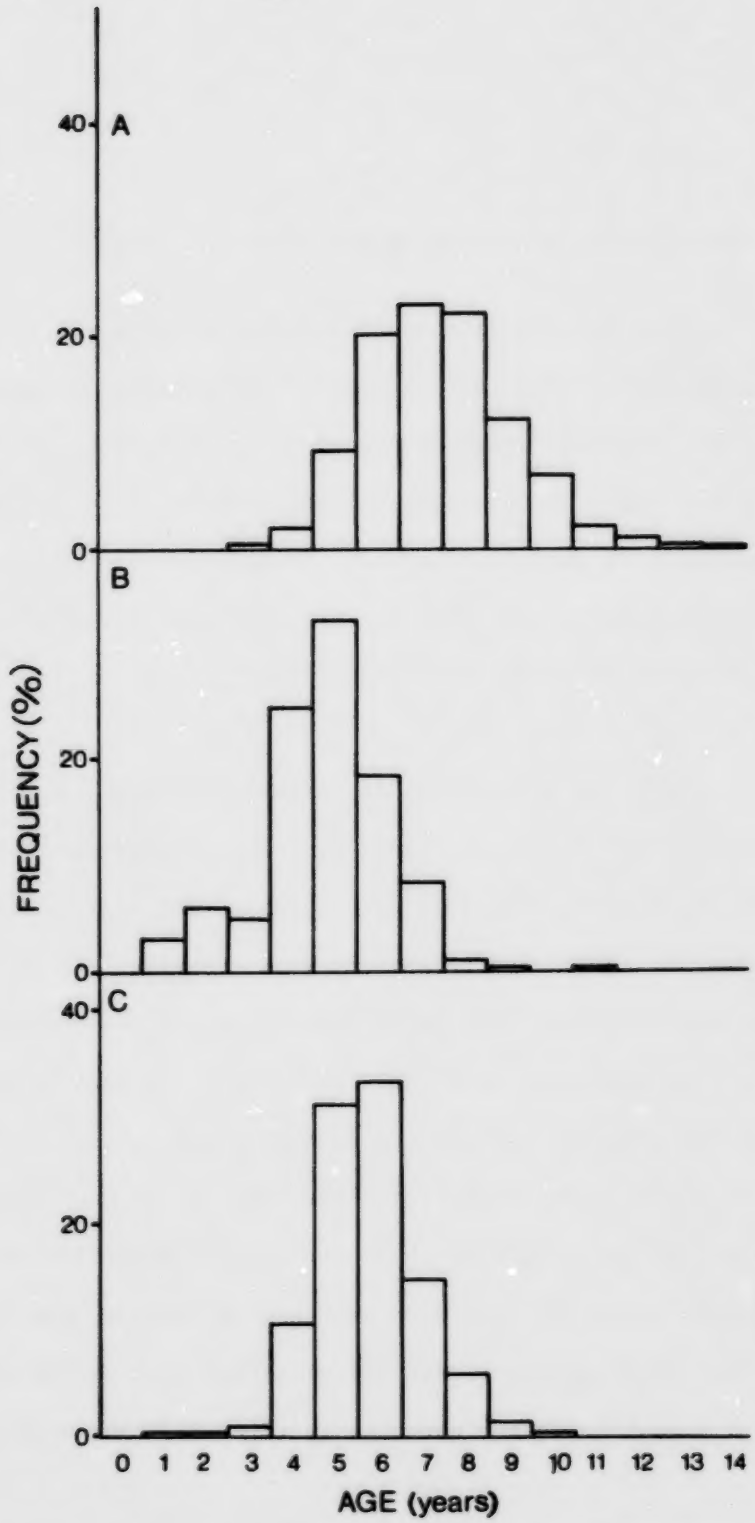

Fig. 2. Age compositions of experimentally caught saugers from the northern (A), channel (B) and southern (C) areas of Lake Winnipeg.

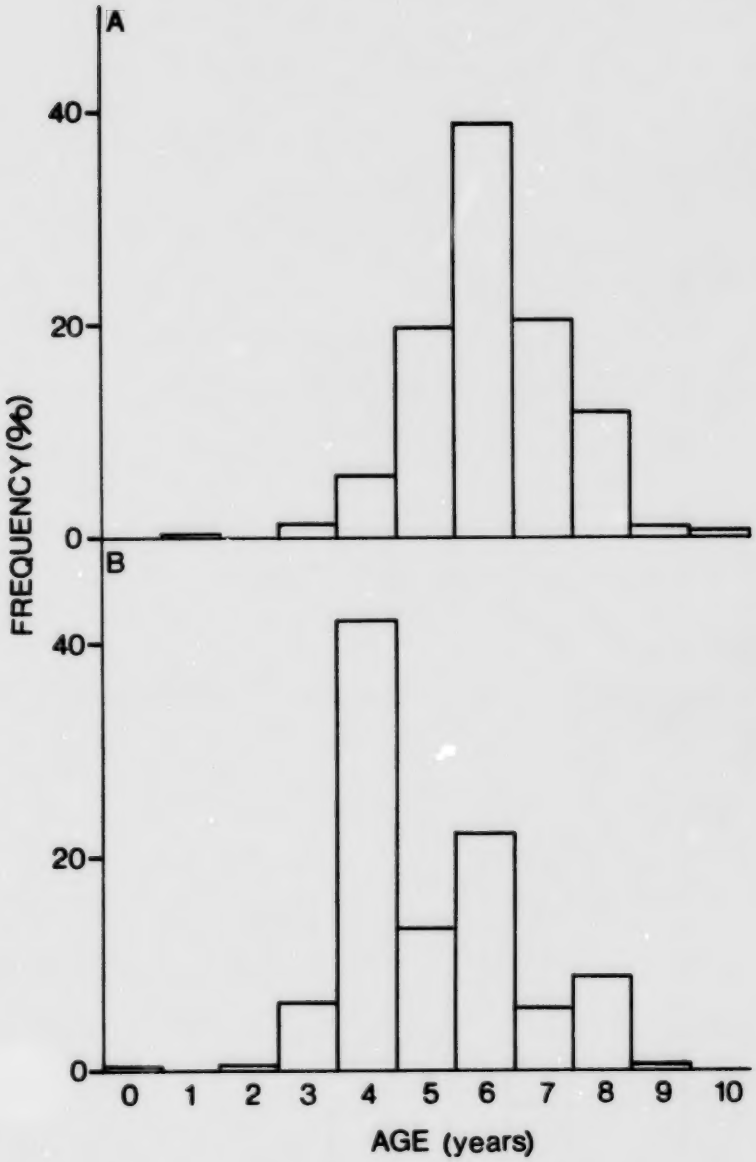

Fig. 3. Age compositions of experimentally caught northern (A) and southern (B) Lake Winnipeg walleyes.

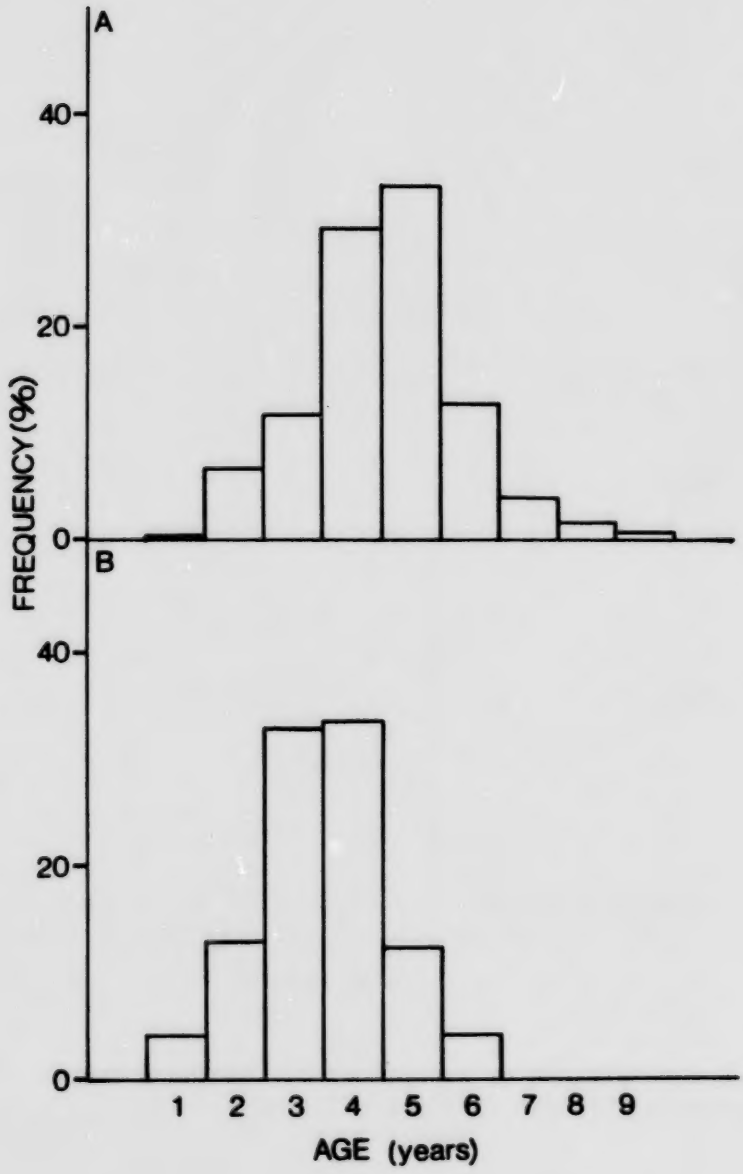

Fig. 4. Age compositions of experimentally caught whitefish from the northern (A) and channel (B) areas of Lake Winnipeg.

age of the northern whitefish stock, 5.54 years, was 1.05 years older than the mean age of the channel whitefish, 4.49 years.

Mortality rates of saugers derived from the descending limbs of catch curves (Fig. 5) were higher in the south basin and channel than in the north basin (Table 13). Survival rates of saugers derived by regression were not significantly different from Robson-Chapman survival rates (Table 13).

An abnormally shaped catch curve of southern walleyes (Fig. 6) produced an instantaneous mortality rate that was lower than that of northern walleyes (Table 13).

The catch curve of channel whitefish was more concave than that of northern whitefish (Fig. 7). The regression estimate of channel whitefish survival was significantly higher than the Robson-Chapman estimate. Robson-Chapman and regression estimates of the northern whitefish survival rate were not significantly different and were almost equal to the Robson-Chapman estimate of channel whitefish survival (Table 13).

The age compositions of commercially caught saugers were more platykurtic in northern Lake Winnipeg in both summer and fall seasons (Fig. 8a, c) that they were in southern Lake Winnipeg (Fig. 8b, d). Southern fishermen were relying strongly on only two age classes while northern fishermen exploited three age classes (Fig. 8, Table 14).

During summer, six and seven year old walleyes dominated the catches of northern fishermen while southern fishermen relied strongly on five and six year old walleyes (Fig.9). The commercial

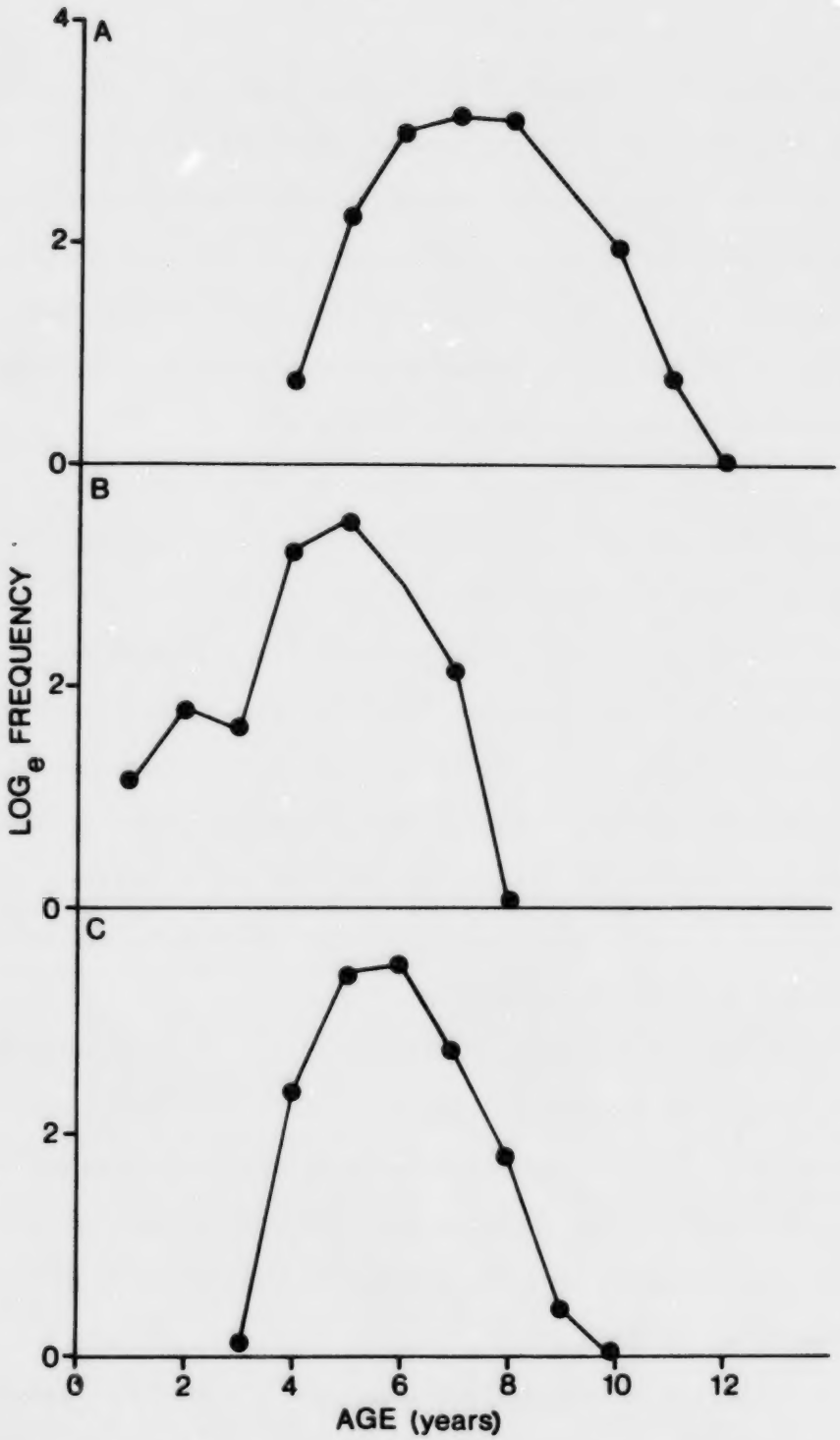

Fig. 5. Catch curves of experimentally caught saugers from the northern (A), channel (B) and southern (C) areas of Lake Winnipeg.

Table 13. Experimental mortality and survival rates estimated by regression and the Robson-Chapman method.

Species	Area	Robson-Chapman			Regression		
		Z	A	S $\pm$ 2 S.E.	Z	A	S
Sauger	North	0.75	0.5276	0.2465 < 0.4693 < 0.6920	0.718	0.5132	0.4868
	Channel	1.20	0.6988	$-9.76 \cdot 10^{4}$ < 0.3012 < 0.6034	1.230	0.7077	0.2923
	South	1.13	0.6770	-0.0193 < 0.3217 < 0.6626	1.010	0.6358	0.3642
Walleye	North	1.13	0.6770	0.0421 < 0.3211 < 0.6001	1.234	0.7077	0.2923
	South	0.76	0.5323	0.1973 < 0.4669 < 0.7366	0.432	0.3495	0.6505
Whitefish	North	1.09	0.6638	0.0240 < 0.3376 < 0.6992	0.950	0.6133	0.3867
	Channel	1.17	0.6896	0.0814 < 0.3099 < 0.5386	1.048	0.2666	0.7334

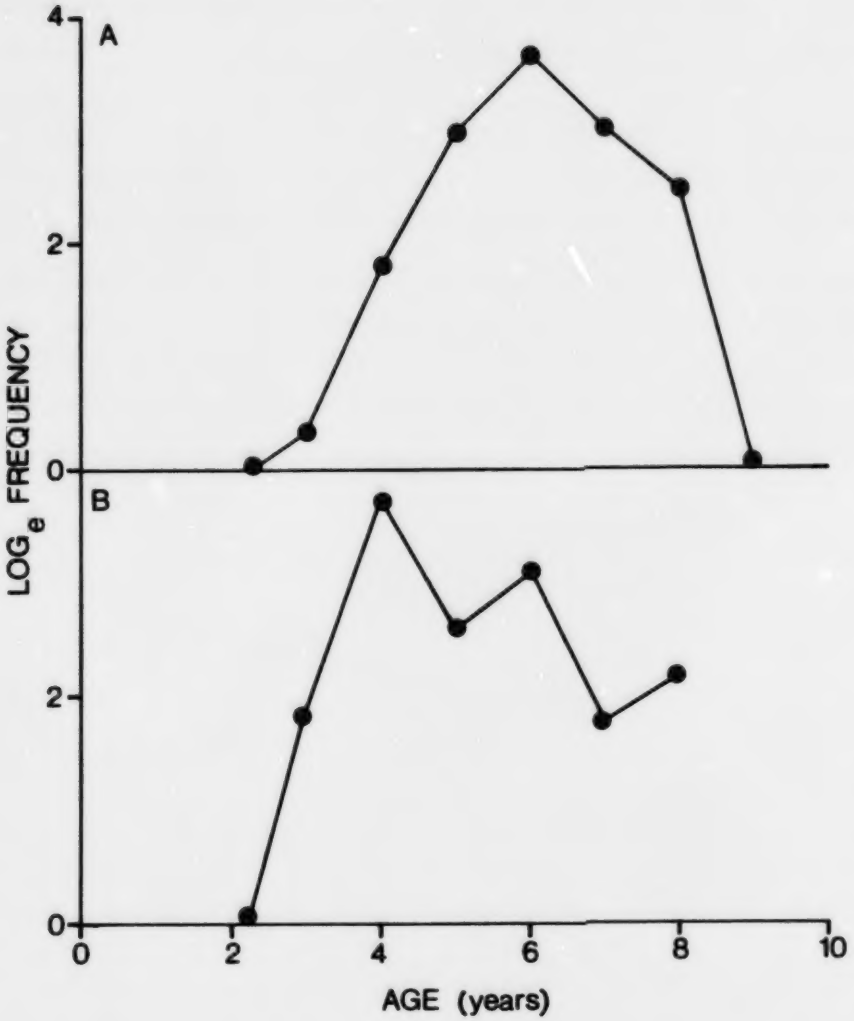

Fig. 6. Catch curves of experimentally caught walleyes from northern (A) and southern (B) Lake Winnipeg.

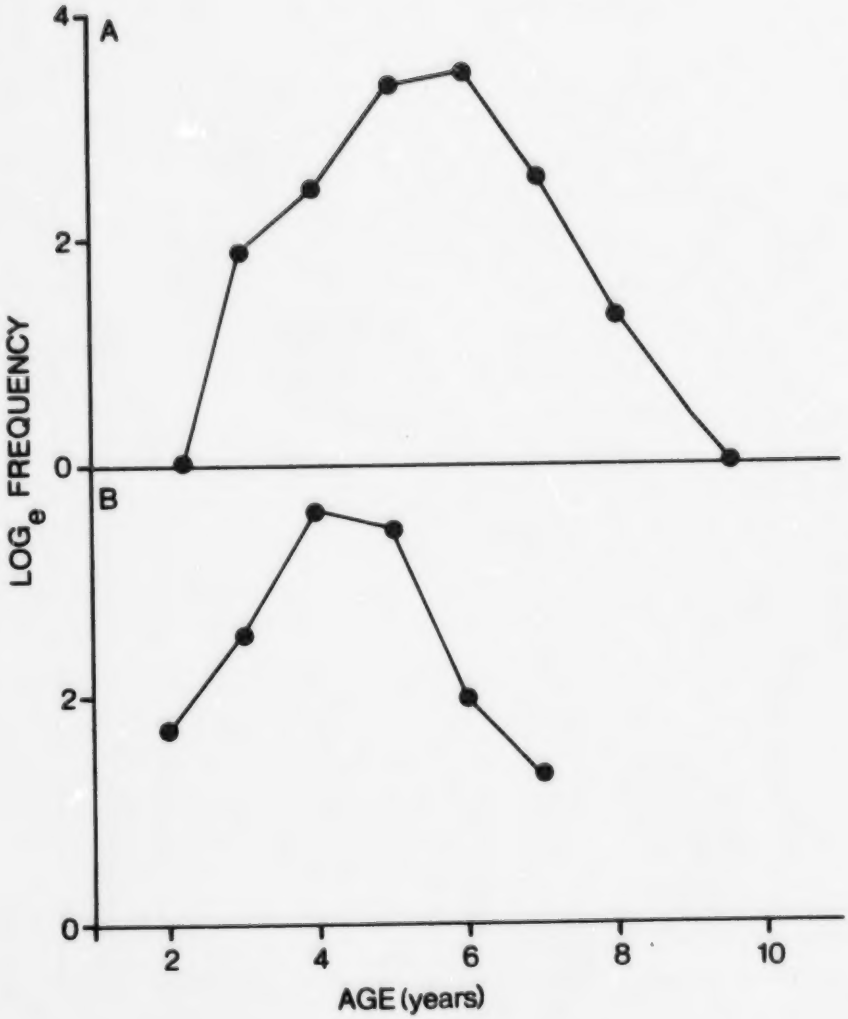

Fig. 7. Experimental catch curves of northern (A) and channel (B) whitefish stocks in Lake Winnipeg.

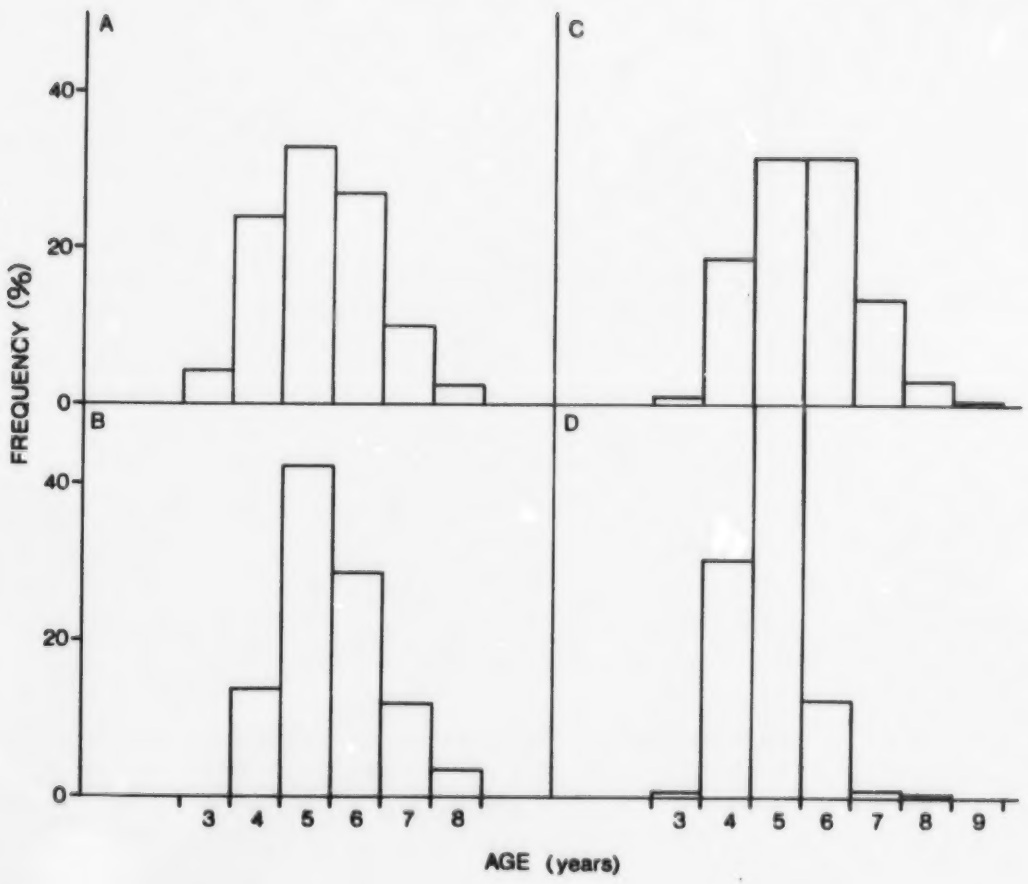

Fig. 8. Age compositions of commercially caught saugers. A - north summer, B - south summer, C - north fall, D - south fall.

Table 14. Age compositions and mean lengths and weights of commercial catches in northern and southern Lake Winnipeg. Numbers in parentheses are percentage frequencies.

Species	Area	Season	Age (years)										Mean length (mm)	Mean weight (gm)
			2	3	4	5	6	7	8	9	10	11		
Sauger	North	Summer		43(4.11)	250(32.76)	343(32.76)	281(26.84)	104(9.93)	25(2.39)	1(.10)			305.45	309.83
		Fall		8(1.07)	140(18.69)	237(31.64)	238(31.78)	101(13.48)	23(3.07)	2(.27)			314.92	357.33
	South	Summer			69(13.80)	211(42.20)	143(28.60)	59(11.80)	17(3.40)	1(.20)			311.59	328.24
		Fall		7(.70)	302(30.20)	556(55.60)	123(12.30)	9(.90)	2(.20)	1(.10)			320.86	375.74
Walleye	North	Summer		1(.11)	18(1.92)	110(11.75)	381(40.71)	268(28.63)	127(13.57)	22(2.35)	9(.96)		415.54	893.40
		Fall	27(5.41)	30(6.01)	113(22.65)	92(18.44)	200(40.08)	24(4.81)	13(2.61)				410.38	877.11
	South	Summer			9(1.81)	151(30.32)	194(38.96)	90(18.07)	40(8.03)	11(2.21)	2(.40)	1(.20)	368.72	611.71
		Fall	176(35.20)	92(18.40)	137(27.40)	46(9.20)	30(6.00)	7(1.40)	11(2.20)	1(.20)			372.62	659.26
Whitefish	North	Summer		1(.07)	122(8.24)	601(40.58)	510(34.44)	186(12.56)	47(3.17)	12(.81)			412.51	929.68[1]
		Fall		6(1.20	56(11.20)	240(48.00)	163(32.60)	31(6.20)	1(.20)	3(.60)			404.26	842.32[1]

1. dressed weight

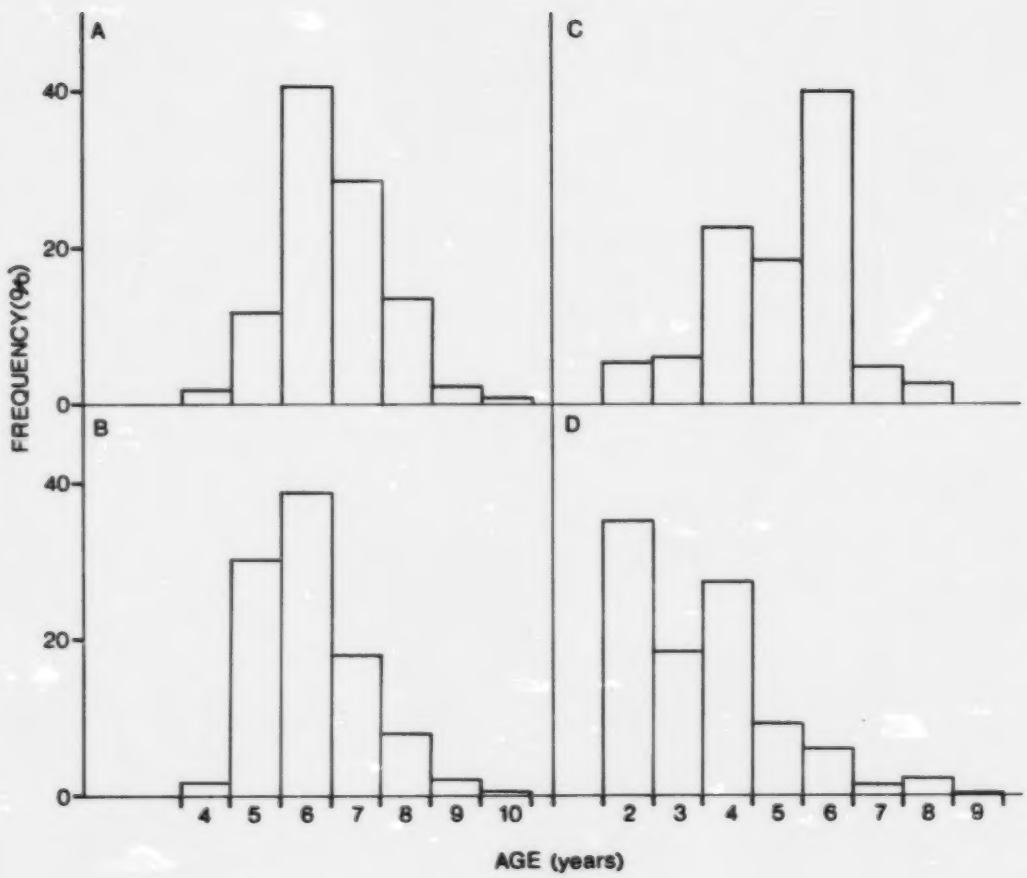

Fig. 9. Age compositions of commercially caught walleyes. A - north summer, B - south summer, C - north fall, D - south fall.

age composition of south basin walleyes changed drastically in autumn. Two and four year old walleyes dominated catches while three, five and six year old age classes appeared weaker in the age composition (Fig. 9, Table 14).

Fishermen from the north channel area (Berens R. and Matheson Is.) tended to catch younger whitefish (Fig.10b) than were caught in northern Lake Winnipeg in the summer season (Fig.10a, c). Five year old whitefish dominated the catches of north channel fishermen in the summer (Fig.10b) while four year old whitefish dominated the autumnal catches (Fig.10d).

Mortality rates derived from the descending limbs of catch curves (Figs. 11-13) indicate the following:

1. mortality and survival rates of northern saugers remained relatively constant from summer to fall while mortality of southern saugers increased dramatically from summer to fall (Table 15).

2. mortality of northern walleyes increased from summer to fall while mortality of southern walleyes decreased from summer to fall (Table 15).

3. mortality of northern whitefish increased from summer to fall.

4. survival rates of northern and southern saugers and walleyes were not significantly different in either the summer or fall seasons (Table 15).

The mean age of the commercial catch of saugers exceeded the mean age of maturity in both basins during both seasons (Table 16). The mean ages of commercial catches of walleyes and whitefish were generally lower than their respective mean ages of

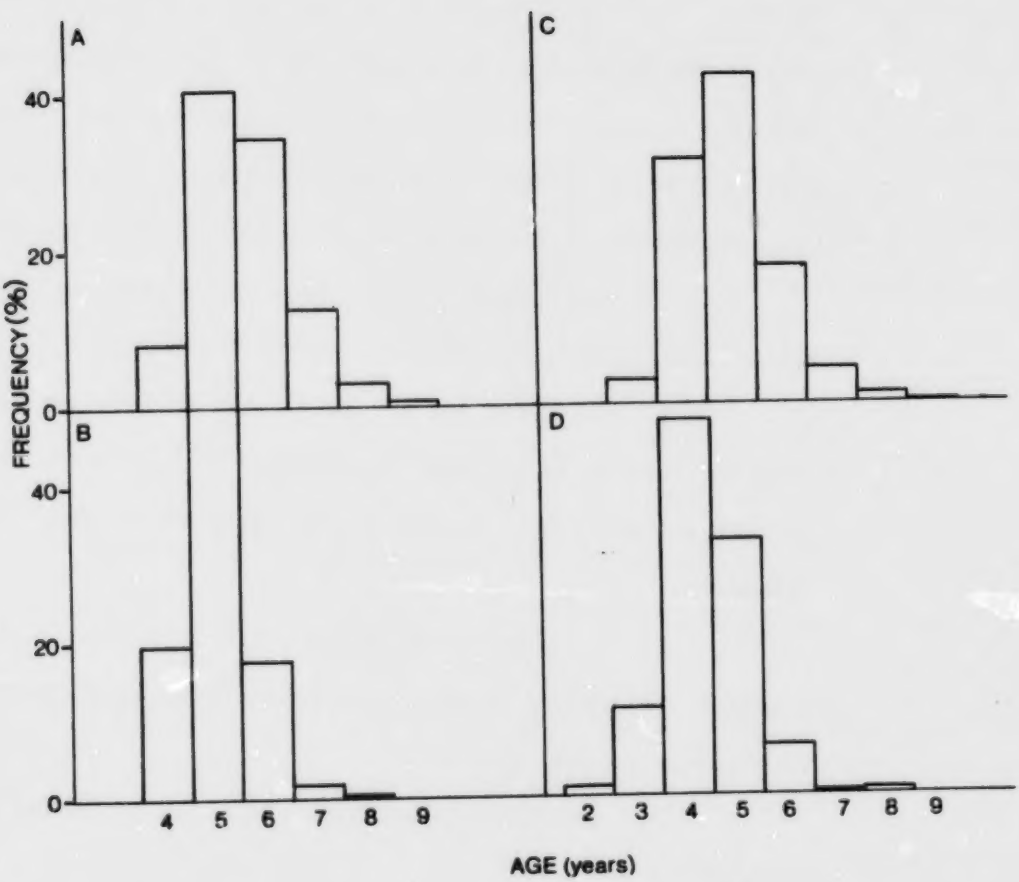

Fig. 10. Age compositions of commercially caught whitefish. A - summer: Grand Rapids, Big Black R., Warren's, Berens R. and Matheson Is. B - Berens R. and Matheson Is. C - Grand Rapids, Big Black R. and Warren's D - fall: Berens R.

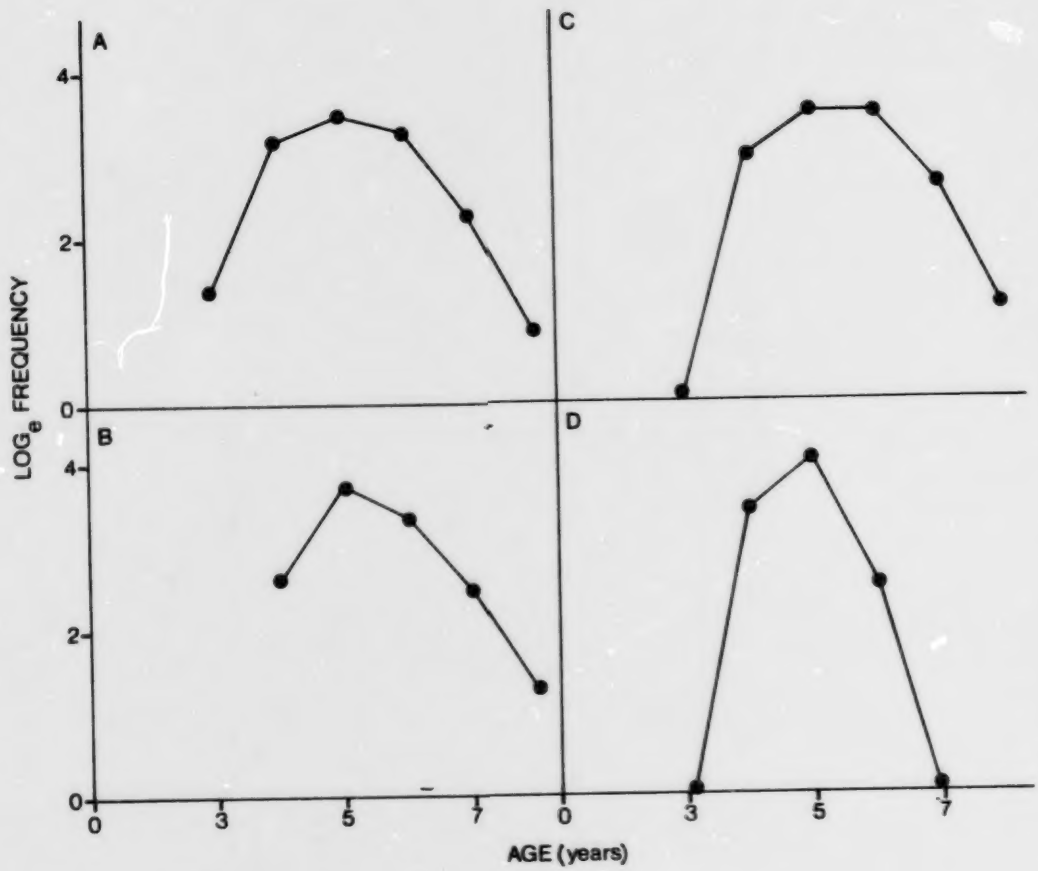

Fig. 11. Catch curves of commercially caught saugers. A - summer: Berens R. and Matheson Is. B - summer: Gimli and Selkirk C - fall: Berens R. and Matheson Is. D - fall: Gimli and Selkirk.

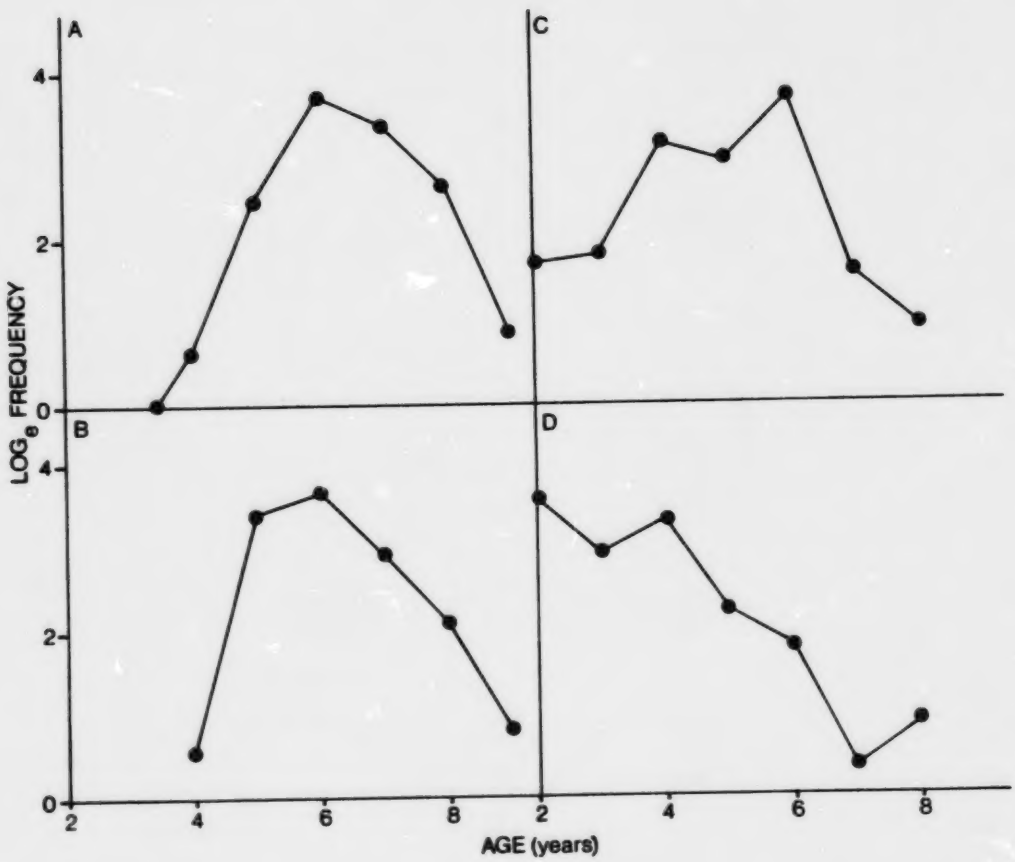

Fig. 12. Catch curves of commercially caught walleyes. A - summer: Big Black R., Grand Rapids and Berens R. B - summer: Selkirk C - fall: Berens R. and Matheson Is. D - fall: Gimli.

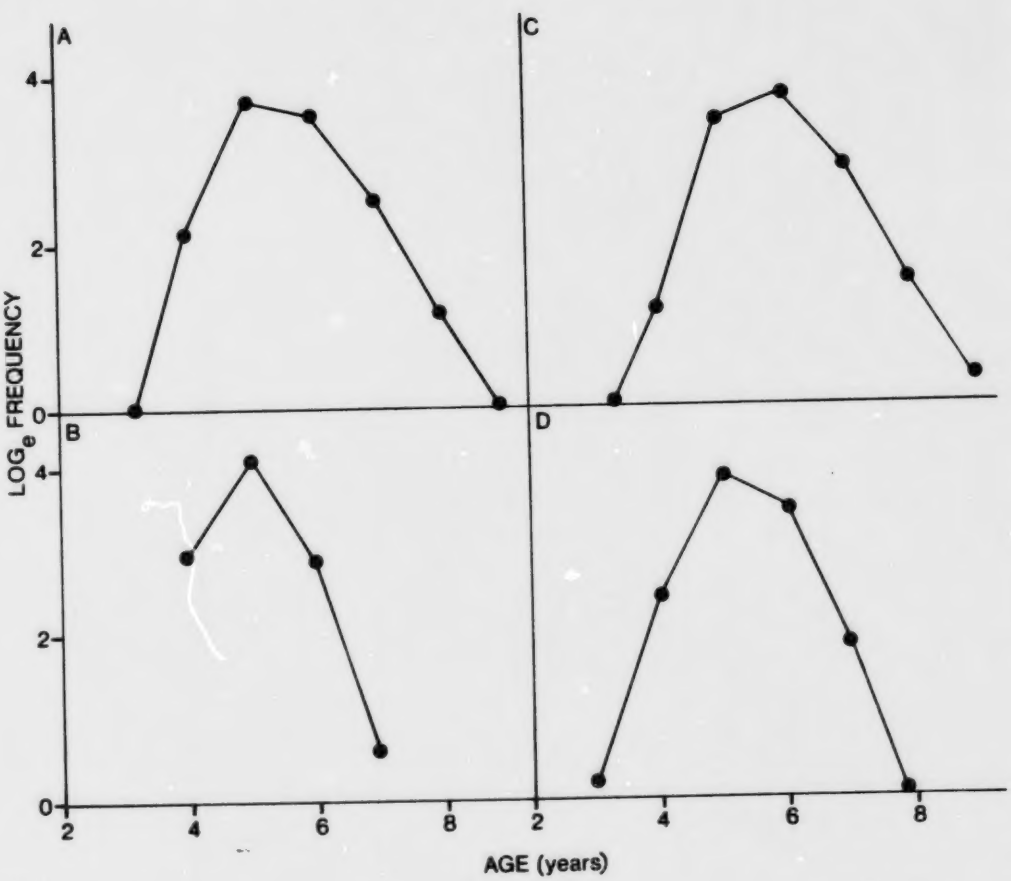

Fig. 13. Catch curves of commercially caught whitefish. A - summer: Grand Rapids, Big Black R., Warren's, Berens R and Matheson Is. B - summer: Berens R. and Matheson Is. C - summer: Grand Rapids, Big Black R. and Warren's D - fall: Beren's R.

Table 15. Mortality rates of commercially caught saugers, walleyes and whitefish from the northern and southern areas of Lake Winnipeg. Survival was estimated according to Robson and Chapman (1961).

Species	Season	Area					
		North			South		
		Z	A	S ± 2 S.E.	Z	A	S ± 2 S.E.
Sauger	Summer	1.24[1]	0.71	0.0337 < 0.2885 < 0.5433	1.14[2]	0.68	0.0750 < 0.3199 < 0.5647
	Fall	1.20[1]	0.70	0.0765 < 0.3082 < 0.5398	2.28[2]	0.90	0.2119 < 0.1020 < 0.4160
Walleye	Summer	1.13[3]	0.68	0.0899 < 0.3219 < 0.5539	1.07[4]	0.66	0.0386 < 0.3434 < 0.6482
	Fall	1.70[1]	0.82	-0.0236 < 0.1826 < 0.3888	0.81[5]	0.55	0.2210 < 0.4430 < 0.6651
Whitefish	Summer	1.20[6]	0.69	0.0848 < 0.3024 < 0.5201	-	-	-
	Fall	1.79[7]	0.83	-0.0522 < 0.1674 < 0.3870	-	-	-

1. Berens R., Matheson Is.
2. Gimli, Selkirk
3. Big Black R., Grand Rapids, Berens R.
4. Selkirk
5. Gimli
6. Big Black R., Grand Rapids, Warren's, Berens R., Matheson Is.
7. Berens R.

Table 16. Mean ages of commercial catches and mean ages of maturity of walleye, sauger and whitefish stocks in Lake Winnipeg.

Species	Area	Season	Mean age of commercial catch (years)	Mean age of maturity[1] (years)	Abrasov's (1967) t^* index (years)
Sauger	North	Summer	5.22	4.61	0.61
		Fall	5.48		0.87
	South	Summer	5.49	3.58	1.91
		Fall	4.84		1.26
Walleye	North	Summer	6.51	7.46	-0.95
		Fall	5.07		-2.39
	South	Summer	6.09	4.99	1.10
		Fall	3.46		-1.53
Whitefish	North	Summer	5.65	6.49	-0.84
		Fall	5.34		-1.15

1. from Table 4

of maturity. Notice that Abrasov's (1967) t index changed from a positive to a negative value from summer to autumn in the south basin walleye fishery.

Species composition

The relative proportions of various species gillnetted during 1980 (Fig. 14, Appendix A) indicate the following:

1. Whitefish were substantially more numerous in the north end that in the channel and southern areas of Lake Winnipeg.

2. Proportions of saugers were substantially higher than proportions of walleyes in the northern and channel areas. In the south, walleyes were slightly less numerous than saugers.

3. Burbot and tullibees were dominant in the channel area.

4. Mooneyes, goldeyes, bass and carp were present at a very low level in southern catches and were absent from northern catches.

5. Freshwater drum dominated the southern species composition.

6. In general, commercially undesirable species were dominant in the south basin and channel areas and were rarely present or absent in the north basin.

Mesh size effects

The mean number of saugers mesh^{-1} was highest in the 3 inch mesh and declined with increasing mesh size in the north and south basins (Table 17-19). The 3 and 3.25 inch meshes caught

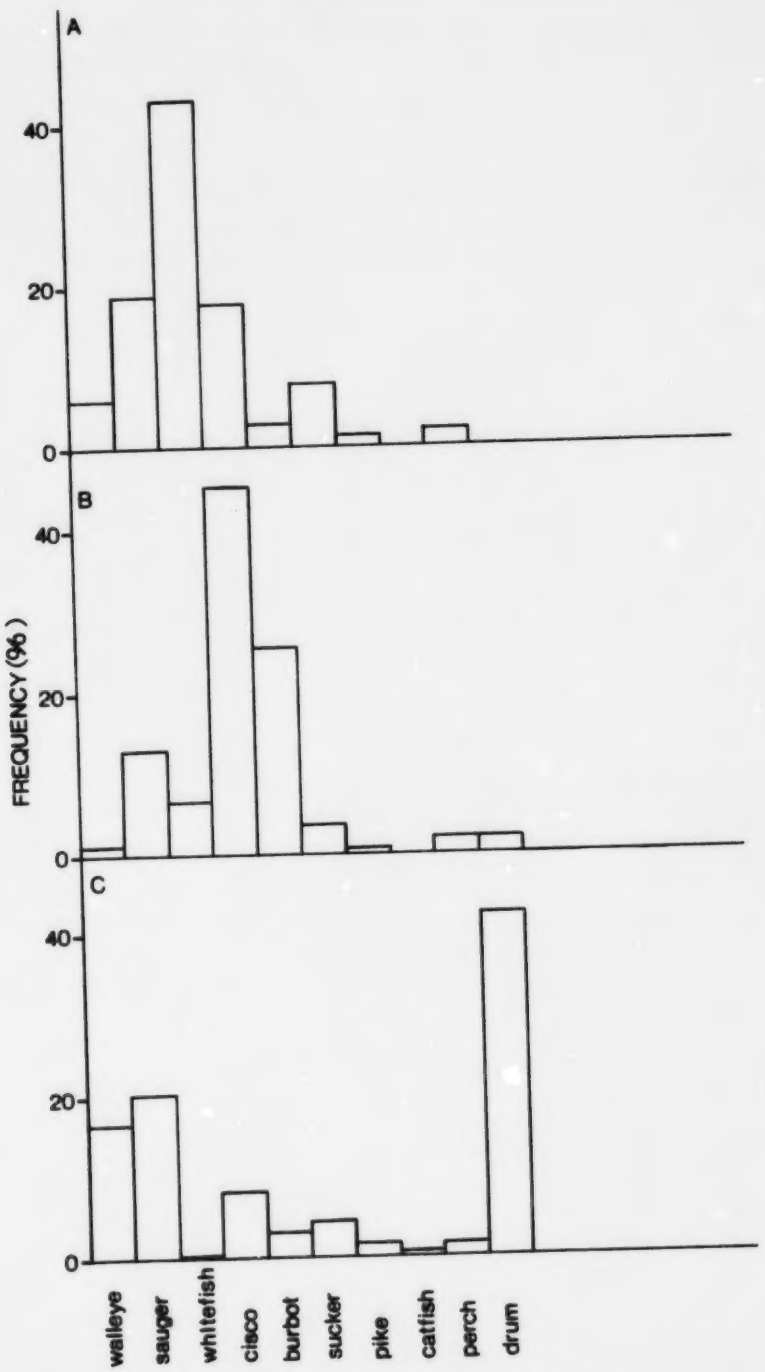

Fig. 14. Species composition of the northern (A), channel (B) and southern areas of Lake Winnipeg determined with gillnets.

Table 17. North basin sauger mesh size effects.

Parameter	Mesh size (inches)						
	3	3.25	3.5	3.75	4	4.25	5 + 5.25
no. fish	305	197	160	86	70	33	60
no. immature	47	22	27	15	13	8	18
% immature	15.41	11.17	16.88	17.44	18.57	24.24	30.00
mean length (mm)	328.88	342.81	353.09	364.33	348.77	329.27	313.30
mean weight (gm)	387.96	463.76	520.69	583.72	534.86	467.27	380.80
Age (years)			Frequency (%)				
1		0.51					1.67
2					1.43		1.67
3					1.43		1.67
4	1.31	1.52	1.88	4.65	1.43	6.06	1.67
5	8.85	4.06	5.63	10.47	18.57	9.09	23.35
6	27.87	22.84	10.63	9.30	10.00	12.12	25.00
7	30.16	28.93	19.38	4.65	12.86	18.18	16.67
8	20.33	20.81	33.13	19.77	22.86	18.18	15.00
9	8.85	14.21	15.63	16.28	15.71	9.09	5.00
10	1.64	5.58	8.75	23.26	7.14	9.09	6.67
11	0.66	1.52	3.13	8.14	2.86	12.12	
12	0.33		1.25	3.49	2.86	3.03	1.67
13			0.63		2.86		
14						3.03	
mean age (years)	6.98	7.33	7.86	8.28	7.54	8.00	6.52
mean biomass mesh $^{-1}$ (kg)	9.861	7.613	6.943	4.183	3.120	1.285	1.904
mean no. fish mesh $^{-1}$	25.42	16.42	13.33	7.17	5.83	2.75	5.00

1980

Table 18. Channel sauger mesh size effects.

Parameter	Mesh size (inches)					
	3	3.25	3.50	3.75	4	4.25
no. fish	59	42	45	66	60	23
no. immature	24	28	19	37	39	19
% immature	40.68	66.67	42.22	56.06	65.00	82.61
mean length (mm)	293.05	273.76	288.49	265.55	248.00	260.96
mean weight (gm)	258.81	221.43	254.89	203.03	159.83	173.04
Age (years)		Frequency (%)				
1		4.76		3.03	8.33	
2	3.39	2.38	2.22	7.58	15.00	
3		11.90	4.44	4.55	5.00	17.39
4	15.25	16.67	20.00	21.21	33.33	26.09
5	47.46	33.33	37.78	30.30	23.33	47.83
6	25.42	14.29	20.00	19.70	8.33	8.70
7	5.08	16.67	11.11	12.12	6.67	
8	3.39			1.52		
9			2.22			
10						
11			2.22			
mean age (years)	5.20	4.81	5.29	4.83	3.99	4.48
mean biomass mesh $^{-1}$ (kg)	3.818	2.325	2.868	3.350	2.398	0.995
mean no. fish mesh $^{-1}$	14.75	10.5	11.25	16.5	15.0	5.75

1980

Table 19. South basin sauger mesh size effects.

Parameter	Mesh size (inches)					
	3	3.25	3.50	3.75	4	4.25
no. fish	196	87	39	60	35	40
no. immature	17	5	5	7	3	2
% immature	8.67	5.75	12.82	11.66	8.57	5.00
mean length (mm)	316.30	313.44	286.23	281.1	282.14	290.90
mean weight (gm)	322.47	319.95	238.33	229.75	229.17	246.63
Age (years)		Frequency (%)				
0				1.67	2.86	
1				1.67	2.86	
2		1.15	2.56	5.00	11.43	
3		1.15	17.95	21.67	45.71	
4	8.16	6.90	41.03	40.00	20.00	7.5
5	23.98	26.44	23.08	18.33	8.57	42.5
6	39.80	37.93	2.56	6.67	2.86	32.5
7	18.88	19.54	7.69	3.33	5.71	15.00
8	8.16	4.60	5.13	1.67		2.50
9	0.51	1.15				
10	0.51	1.15				
mean age (years)	5.98	5.89	4.49	4.06	3.44	5.63
mean biomass mesh $^{-1}$ (kg)	3.511	1.546	0.516	0.766	0.446	0.548
mean no. fish mesh $^{-1}$	10.89	4.83	2.17	3.33	1.94	2.22

1980

two to three times as many saugers in the north basin as they did in the south basin. Mean ages and mean lengths of saugers caught in each mesh of the experimental gang were substantially lower in the channel and south basin than they were in the north basin (Table 17-19). Frequencies of immature saugers mesh^{-1} were highest in the channel and lowest in the south basin (Fig. 15). The mean biomass mesh^{-1} of saugers decreased with increasing mesh size in all three areas (Fig. 16). Each mesh of the experimental gang caught the highest biomass in the north basin and the lowest biomass in the south basin (Fig. 16).

The 3.5 inch mesh caught the highest mean number of walleyes in both the north and south basins (Table 20,21). Mean numbers of walleyes caught mesh^{-1} were slightly higher in the north basin than in the south basin. Mean ages of walleyes caught in all meshes of the experimental gang were higher in the north basin than in the south basin (Tables 20,21). Mean lengths of walleyes caught in 3 to 4 inch meshes were slightly higher in the north basin than in the south basin. Consequently, mean biomasses of walleyes caught in the meshes of the experimental gang were slightly higher in the north basin (Fig. 17). Frequencies of immature walleyes mesh^{-1} decreased faster with increasing mesh size in the south basin than in the north basin. Frequencies of immature walleyes were higher in all meshes in the north basin than in the south basin (Fig. 18).

Mean ages and mean lengths of north basin whitefish increased regularly with increasing mesh size (Table 22) The mean number of whitefish mesh^{-1} increased rapidly from the 3 inch mesh to the 4 inch mesh and decreased thereafter (Table 22).

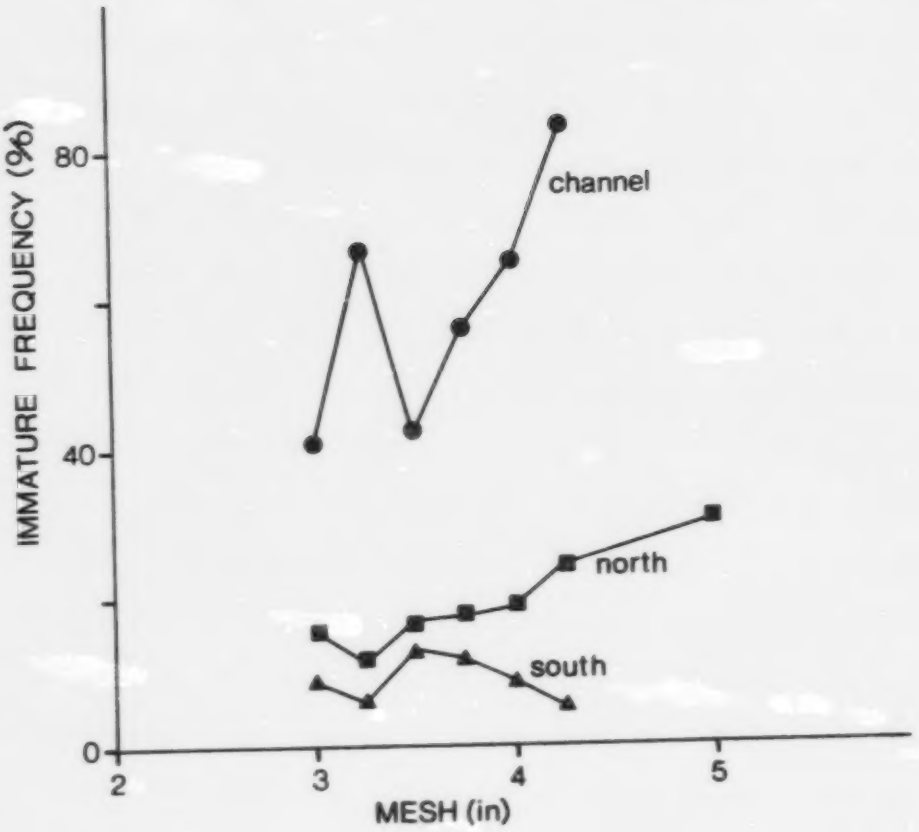

Fig. 15. Changes in frequencies of immature saugers caught in various mesh sizes.

1980

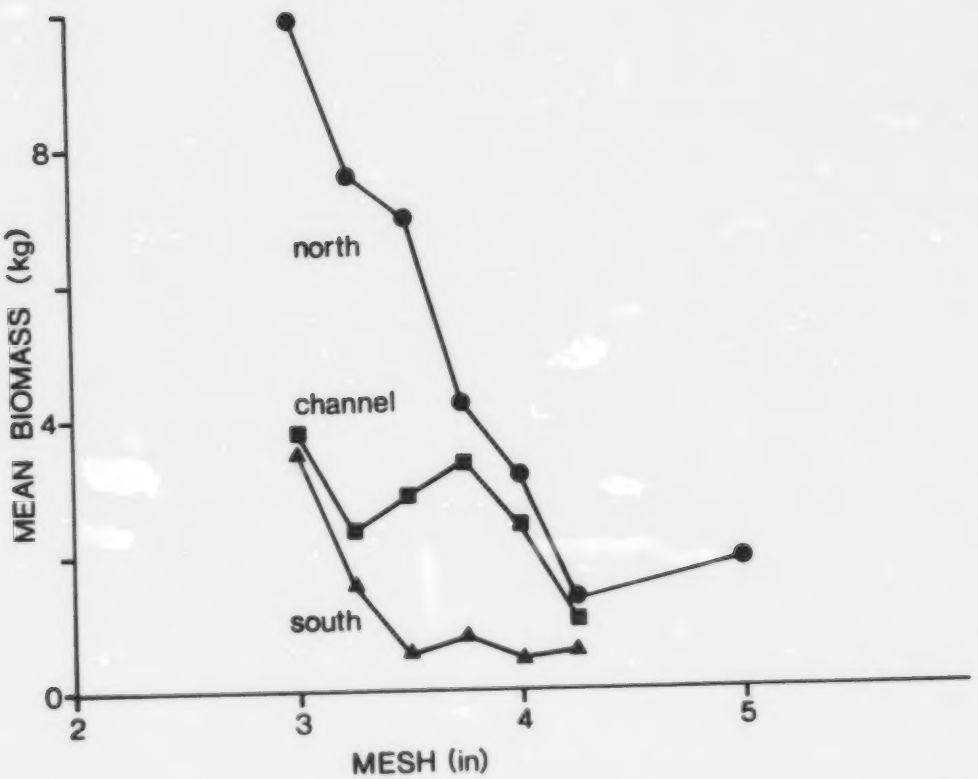

Fig. 16. Changes in mean biomass of saugers in relation to mesh size in the three major areas of Lake Winnipeg.

1980

Table 20. North basin walleye mesh size effects.

Parameter	Mesh size (inches)						
	3	3.25	3.5	3.75	4	4.25	5 + 5.25
no. fish	59	65	68	44	31	16	6
no. immature	49	55	56	32	21	13	3
% immature	83.05	84.62	82.35	72.73	67.74	81.25	50.00
mean length (mm)	348.78	371.86	387.60	401.23	417.81	423.69	411.00
mean weight (gm)	487.97	607.54	686.76	764.55	847.42	944.38	953.33
Age (years)	Frequency (%)						
1	1.69						
2	1.69						
3	10.17	1.54	1.47				16.67
4	38.98	9.23	7.35				
5	27.12	23.08	17.65	2.27	12.9	6.25	16.67
6	11.86	38.46	44.12	52.27	38.71	31.25	16.67
7	6.78	21.54	16.18	31.82	22.58	37.50	
8	1.69	4.62	13.24	11.36	22.58	18.75	50.00
9		1.54		2.27	3.23	6.25	
mean age (years)	4.59	5.89	6.06	6.59	6.65	6.88	6.33
mean biomass mesh $^{-1}$ (kg)	2.39917	3.29083	3.89167	2.80333	2.18917	1.25917	4.7667
mean no. fish mesh $^{-1}$	4.92	5.42	5.67	3.67	2.59	1.33	0.50

1980

1980

Table 21. South basin walleye mesh size effects.

Parameter	Mesh size (inches)					
	3	3.25	3.5	3.75	4	4.25
no. fish	69	87	110	41	30	38
no. immature	52	50	43	16	4	1
% immature	75.36	57.47	39.09	39.02	13.33	2.63
mean length (mm)	345.97	365.92	380.85	392.29	425.10	473.84
mean weight (gm)	482.97	544.79	623.05	718.90	906.17	1216.05
Age (years)	Frequency (%)					
0				2.44		
1						
2	2.90					
3	21.74	8.05	1.82	31.71	23.33	2.63
4	42.03	57.47	52.73	24.39	6.67	2.63
5	11.59	13.79	15.45	29.27	30.00	28.95
6	17.39	17.24	21.82	2.44	6.67	26.32
7	2.90	1.15	5.45	9.76	33.33	36.84
8	1.45	2.3	1.82			2.63
9			0.91			
mean age (years)	4.33	4.53	4.85	4.22	5.20	6.00
mean biomass mesh $^{-1}$ (kg)	1.851	2.633	3.808	1.638	1.510	2.567
mean no. fish mesh $^{-1}$	3.83	4.83	6.11	2.28	1.67	2.11

1980

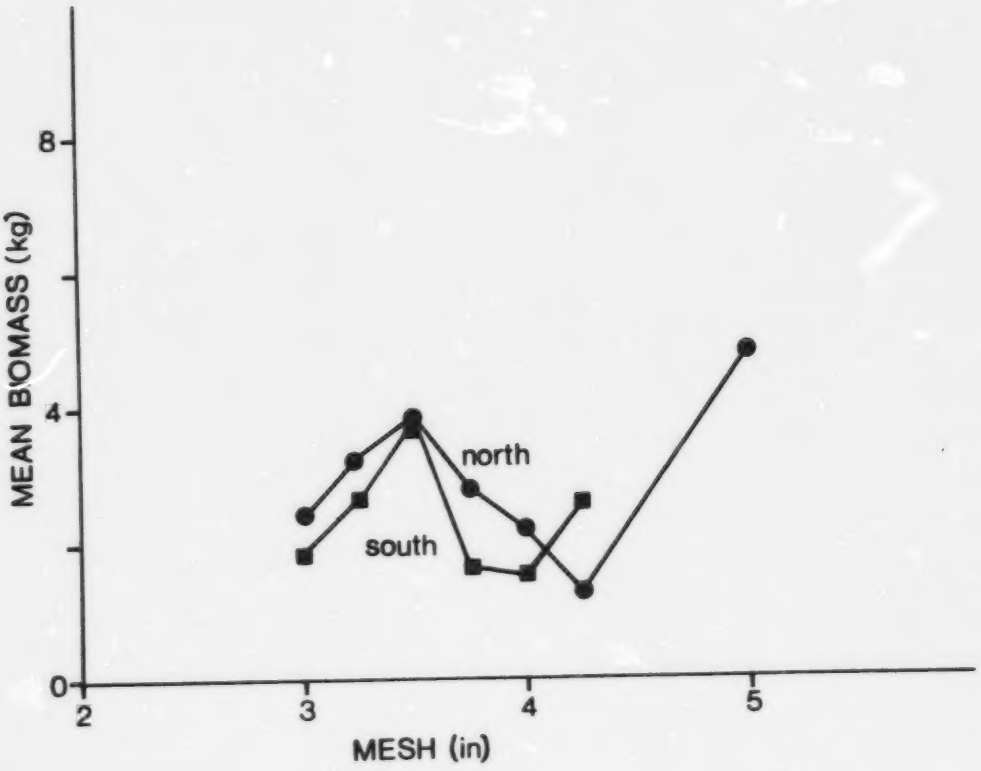

Fig. 17. Changes in mean biomass of walleyes in relation to mesh size in northern and southern Lake Winnipeg.

1980

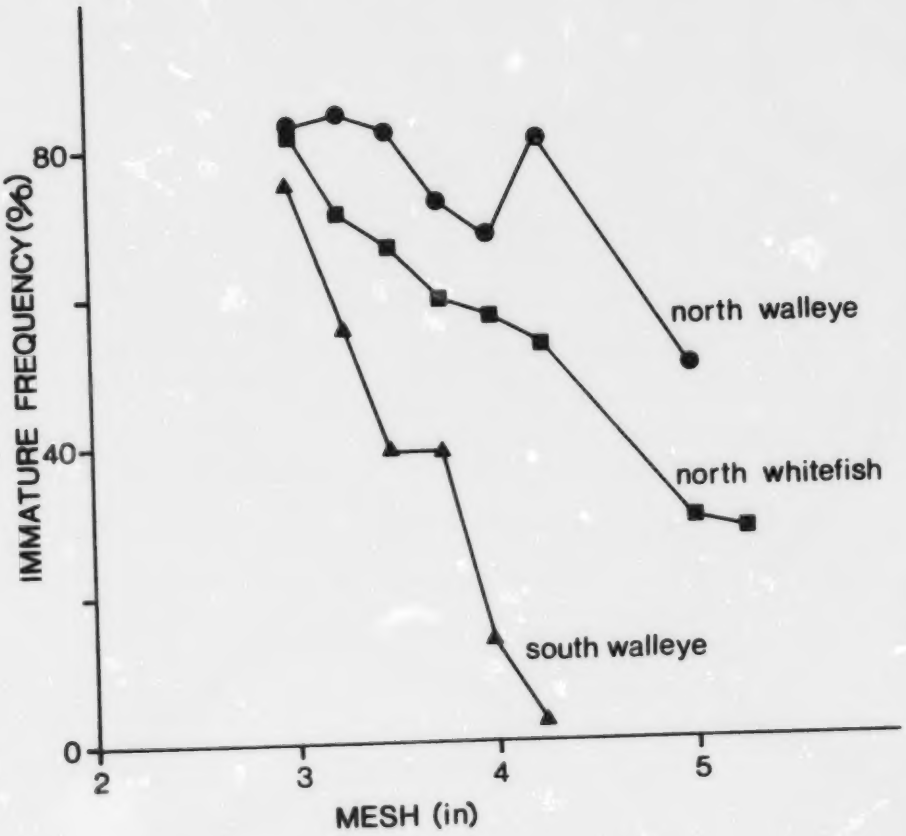

Fig. 18. Changes in frequencies of immature walleyes and whitefish caught in various mesh sizes.

1980

Table 22. North basin whitefish mesh size effects.

Parameter	Mesh size (inches)							
	3	3.25	3.5	3.75	4	4.25	5	5.25
no. fish	153	240	319	359	403	293	175	135
no. immature	126	171	212	214	231	157	52	38
% immature	82.35	71.25	66.46	59.61	57.32	53.58	29.71	28.15
mean length (mm)	331.71	346.27	365.50	377.53	383.58	388.70	417.63	420.25
mean weight (gm)	546.01	650.75	759.15	809.28	851.81	903.92	1132.74	1215.78
Age (years)			Frequency (%)					
2	1.96	0.83	0.31					
3	28.10	23.75	7.21	1.39	0.74	0.68	0.57	
4	22.88	16.67	18.18	11.98	10.17	8.87	0.57	0.74
5	26.14	24.58	36.05	37.60	32.51	27.99	13.71	18.52
6	13.73	27.50	27.27	35.38	38.71	44.37	34.29	31.85
7	3.27	4.58	7.21	9.19	12.66	12.97	32.57	33.33
8	3.27	1.25	2.19	2.79	3.97	3.07	11.43	8.15
9	0.65	0.83	0.31	1.11	0.99	1.71	5.71	3.70
10			1.25	0.56	0.25	0.34	1.14	3.70
mean age (years)	4.48	4.77	5.22	5.55	5.70	5.78	6.61	6.55
mean biomass mesh $^{-1}$ (kg)	6.962	13.015	20.180	24.211	28.607	22.071	16.519	13.678
mean no. fish mesh $^{-1}$	12.75	20	26.58	29.92	33.58	24.42	14.58	11.25

1980

Consequently, the 4 inch mesh caught the highest biomass of whitefish (Fig. 19). Frequencies of immature whitefish were highest in the 3 inch mesh and declined regularly with increasing mesh size (Fig. 18).

Commercial catches and fishing effort from 1972 to 1979

Actual yields and numbers of deliveries in the three major areas of Lake Winnipeg from 1972 to 1979 were compiled from F.F.M .C. records (Table 23). Assuming that catch per delivery reflects catch per unit effort, the following trends have occurred:

1. In the north and south basins, effort was low in 1972 and increased until the latter part of the decade.

2. Yields of saugers showed annual fluctuations but seemed to reach a maximum in 1975 in the north and channel areas. Sauger yields have declined irregularly in the south basin since 1973. Walleye yields increased steadily from 1972 to 1977 in the channel and north basin but have decreased in the south basin since 1973.

3. Since 1972, there has been a general increase in catch unit effort^{-1} (lbs. delivery^{-1}) for north basin and channel walleye stocks while catch unit effort^{-1} (c.u.e.) has generally declined for south basin walleye stocks. Channel and south basin sauger c.u.e. has shown an overall decrease since 1972. North basin sauger c.u.e. increased from 1972 to 1975 and decreased thereafter.

4. Whitefish yields, deliveries and c.u.e. in the north basin have shown overall increases since 1972.

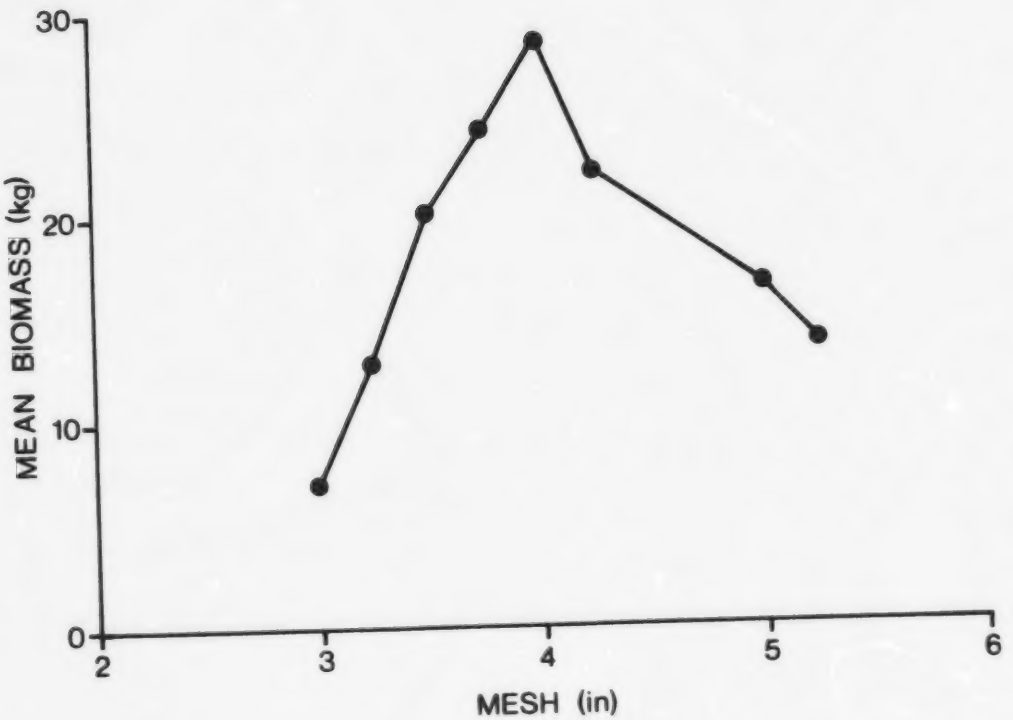

Fig. 19. Changes in mean biomass of whitefish in relation to mesh size in northern Lake Winnipeg.

1980

Table 23. Catches (lbs) and deliveries of saugers, walleyes and whitefish from the three major areas of Lake Winnipeg, 1972-1978.

Species	Area	Parameter	Year						
			1972	1973	1974	1975	1976	1977	1978	1979
Sauger	North	No. deliveries	426	2955	3111	5228	5800	5376	6311	6726
		Total catch	1427	41914	93247	822903	559655	354874	250959	222845
		Catch/delivery	3.35	14.18	29.97	157.40	96.49	66.01	39.77	33.13
	Channel	No. deliveries	123	5039	7164	9478	8186	10242	9944	10006
		Total catch	156876	1255329	1115029	2065554	1688352	1835835	1463509	1112229
		Catch/delivery	1275.42	249.12	155.64	217.93	206.25	179.25	147.18	111.16
	South	No. deliveries	963	14736	13126	9047	9122	9478	8391	8531
		Total catch	536779	2590052	2164584	711906	906825	988806	1141246	1208620
		Catch/delivery	557.40	175.76	164.91	78.69	99.41	104.33	136.01	141.67
Walleye	North	No. deliveries	426	3445	3491	5504	5790	5773	6306	6726
		Total catch	43166	200784	305754	582866	808436	851786	739548	624545
		Catch/delivery	101.33	58.28	87.58	105.90	139.63	147.55	117.28	92.86
	Channel	No. deliveries	123	5039	7164	9478	8186	10242	9944	10006
		Total catch	9015	242849	419147	711469	1107908	1119862	1083432	1115763
		Catch/delivery	73.29	48.19	58.51	75.07	135.34	109.34	108.95	111.51
	South	No. deliveries	963	14736	13126	9047	9122	9474	8391	8801
		Total catch	208716	1954944	1676163	1654473	1571167	1604642	1165662	1225493
		Catch/delivery	216.74	132.67	127.70	182.88	172.24	169.37	138.92	139.29
Whitefish	North	No. deliveries	426	3445	3491	5452	5790	5773	6304	6726
		Total catch	485874	843835	912236	1892999	1812573	2360158	3193235	3033476
		Catch/delivery	1140.55	244.95	261.31	347.21	313.05	408.83	506.54	451.01
	Channel	No. deliveries	-	3055	5811	8632	8006	9891	9922	9594
		Total catch	-	3109	7269	31789	61615	218899	503845	914546
		Catch/delivery	-	1.02	1.25	3.68	7.70	22.13	50.78	95.32
	South	No. deliveries	643	13924	12816	8548	8619	9167	8009	8706
		Total catch	16500	1056991	984866	28319	173968	74430	23776	129670
		Catch/delivery	25.66	75.91	76.85	3.31	20.18	8.12	2.97	14.89

DISCUSSION

Maturity regimes

The 1979 maturity curves of experimentally caught saugers, walleyes and whitefish were corrected to eliminate the addition of unity to $\frac{k - y}{y}$ (see methods section) (Table 24). These corrected curves are not directly comparable to their 1980 counterparts because, in 1979, the north basin was sampled in spring and the south basin was sampled in autumn while in 1980 all the experimental sampling was conducted during one short time interval. Significant maturity curves for saugers were derived in the spring but not in autumn (Olynyk 1980). Thus the 1980 maturity curves for saugers (and probably for walleyes) are more reliable than their 1979 counterparts. In spite of these shortcomings, the maturity rates of saugers increased slightly and the mean ages of sauger maturity has decreased since 1979. The maturity rates of north basin and south basin walleyes have increased substantially since 1979. The mean age of maturity of south basin female walleyes has decreased from 7.5 to 5.4 years since 1979. The mean age of whitefish maturity has increased since 1979 with a concomitant decrease in maturity rates.

In 1980, south basin walleyes matured faster than north basin walleyes. Female walleyes in both basins matured at the same rate but south basin walleyes began maturing at a much younger age than north basin walleyes.

Table 24. Corrected 1979 maturity curves of saugers, walleyes and whitefish from the three major areas of Lake Winnipeg.

Species	Area	Type	Linear equation $-\log_e (\frac{k - y}{y}) = -bX_o + bX$	X_o (years)	Correlation coefficient	Test F ratio and d.f.
Sauger	North	Female	-	-	-	-
		Combined	Y = -5.83 + 1.32X	4.43	0.949	17.98 (1,2)*
	South	Female	Y = -3.52 + 1.37X	2.57	0.956	10.70 (1,1)*
		Combined	-	-	-	-
Walleye	North	Female	Y = -7.43 + 1.07X	6.92	0.970	64.02 (1,4)
		Combined	Y = -6.10 + 0.87X	6.99	0.983	83.87 (1,3)
	South	Female	Y = -5.43 + 0.72X	7.54	0.948	35.25 (1,4)
		Combined	Y = -1.81 + 0.46X	3.89	0.813	5.85 (1,3)*
Whitefish	North	Female	Y = -4.37 + 1.12X	3.90	0.959	34.46 (1,3)
		Combined	Y = -8.51 + 1.84X	4.63	0.956	32.21 (1,3)

* non-significant at P = 0.05

As in 1979, northern saugers matured at a slower rate than channel saugers and channel saugers matured slower than south basin saugers. Differences in maturity rates were not statistically different but differences in mean ages of sauger maturity were statistically different. The mean age of southern sauger maturity was 3.7 years while in the north basin, it was 5.3 years.

Growth regimes

No significant differences in the slopes of age-specific length-weight curves of saugers occurred among the major areas but the north basin sauger length-weight curve was significantly higher elevated than its southern counterpart. This implies that at any given length, northern saugers weigh more than southern saugers.

Since 1979, the slope of the northern walleye length-weight curve has decreased from 3.156 to 2.884. In 1980, the slopes and elevations of northern and southern walleye length-weight curves were statistically identical.

The slope and elevation of the northern whitefish length-weight curve have not changed since 1979.

Gillnet selectivity affects slopes of length-weight curves. The youngest fish caught in nets usually have high weight to length ratios implying that they lie above the true length-weight curve. The points on the length-weight curves presented in this report are age-specific mean lengths and mean weights. Thus the derived equations describe the "age class length-weight relationships". A line fitted through individual lengths and weights would predict smaller weights at a given length. In spite of this, spatial and temporal differences in slopes

and elevations of age-specific length-weight curves may indicate fishery effects as long as each curve is fitted consistently from year to year.

Asymptotic lengths, L_∞, of saugers in all three major areas of Lake Winnipeg increased since 1979. The southern sauger L_∞ estimate remains lower than that of the channel and north basin.

L_∞ estimates for walleyes from both northern and southern basins decreased since 1979 and the spatial differences between L_∞ estimates in 1980 was minimal. L_∞ estimates for whitefish from the north and channel areas have also decreased dramatically.

Exponential growth rates of saugers in all three major areas of Lake Winnipeg have increased since 1979 but Brody growth coefficients from all three areas decreased. This is probably due to the fact that asymptotic sizes of saugers from all three areas increased since 1979.

The exponential growth rate of north basin whitefish decreased slightly since 1979. The decrease in the whitefish L_∞ estimate caused the Brody growth coefficient to increase. In 1980, enough whitefish were captured in the channel area to construct growth curves. The channel whitefish displayed a slower exponential growth rate and a lower Brody growth coefficient and L_∞ than northern whitefish did.

Since experimental fishing effort was much lower in the channel than in the north basin, fewer older channel whitefish were captured. Inadequate numbers of older whitefish probably caused differences in growth parameters between channel and north basin whitefish. It is probably more likely that north basin

whitefish are expanding their territory to include the north channel area.

Exponential growth rates of walleyes increased in both basins since 1979. Both walleye stocks are growing at the same rate but the southern walleye growth curve is more elevated than its northern counterpart.

Age compositions, catch curves and mortality rates

Mean weighted ages of experimentally caught north basin and channel saugers decreased slightly since 1979 but the mean age of southern saugers increased by 1.3 years. Mean weighted age of walleyes increased by 0.89 years in the south basin and by 0.77 years in the north basin since 1979. The mean weighted age of the northern whitefish stock has remained unchanged since 1979.

Mortality rates of saugers in the north basin and channel increased since 1979. Mortality rates of southern saugers decreased by about 20% since 1979. Mortality rates of northern walleyes increased slightly while mortality of southern walleyes decreased since 1979. This anomaly is related to the irregularly shaped descending limb of the southern walleye catch curve. Whitefish mortality rates have remained essentially static since 1979.

Mortality rates of commercially caught saugers, walleyes and whitefish continued to exhibit the same spatial and temporal trends in 1980 as they did in 1979 (Lysack 1980). In general, mortality rates increased from summer to fall and mortality rates increased from the north to the south end of the lake. Anomalies in these trends were due to the appearance of relatively weak

cohorts especially in autumnal walleye catches. Note that the weak cohorts appearing in experimental catches (Fig. 5) closely correspond to weak cohorts appearing in commercial catches (Fig. 11). Weak cohorts were not observed in either experimental or commercial age compositions in 1979 because scale ages were not always correct (Lysack 1980). In 1980, no differences between scale ages and otolith ages occurred until walleyes were about 9 years old (Appendix B). Since the 1980 ageing was more precise, the true relative strengths of cohorts emerged in the age compositions. Also, since scale ages agreed with otolith ages for very young fish, one and two year old walleyes and saugers appeared stronger in commercial and experimental age compositions than in previous years.

In the north basin, fishermen are strongly exploiting one age class of saugers that have not attained the mean age of maturity. In the south basin, most commercially caught saugers have attained the mean age of maturity due to highly accelerated growth and maturity rates but only two age classes continue to support the south basin sauger fishery. In the north basin, a great majority of commercially caught walleyes have not attained the mean age of maturity and northern walleye stocks are beginning to respond to exploitation by increasing their growth rate and maturity rate. In the south basin, the summer fishery strongly exploits one immature age class of walleyes but, as autumn approaches, the majority of the walleye catch consists of immature fish.

Mesh size effects

As in 1979, analyses of mean numbers, mean lengths and mean

ages of fish caught over a range of experimental meshes produced less comprehensive patterns than mean biomass per mesh over a range of mesh sizes. The mean biomass of saugers caught in any mesh in the south basin has decreased dramatically since 1979. In the north basin, the relationship of sauger biomass per mesh and mesh size has remained relatively unchanged since 1979 (Lysack 1980). Walleye biomass caught in small meshes in both basins decreased since 1979. In 1980, the 3.75 inch mesh caught the greatest walleye biomass in both basins. Three to four inch meshes continued to catch a higher walleye biomass in the north basin in 1980. Relatively minor changes occurred in the relation of whitefish biomass per mesh and mesh size since 1979.

The relation of frequencies of immature fish and increasing mesh size were largely unexplainable in 1979 for the channel and south basin because these areas were sampled in autumn. In 1980, the expected decrease in frequency of immature fish with increasing mesh size occurred for northern walleyes and whitefish, southern walleyes and southern saugers. Channel and north basin saugers did not follow this trend. The frequency of immature walleyes declined more rapidly with increasing mesh size in the south basin than in the north basin. Frequencies of immature saugers in all mesh sizes in the south basin were lower than they were in the north basin. These trends are expected since heavier fishing pressure in the south basin is forcing walleyes and saugers to grow and mature at faster rates.

SUMMARY AND RECOMMENDATIONS

In comparison to north basin walleye and sauger stocks, channel and south basin walleyes and saugers are suffering from

overexploitation. Mortality rates of southern stocks are high and temporal changes in the shapes of southern catch curves indicate that the resiliency of southern stocks to high fishing pressure is deteriorating. Walleye and sauger stocks in southern Lake Winnipeg are attempting to compensate by growing and maturing at extremely high rates. Northern walleye stocks are beginning to show signs of compensatory increases in growth and maturity. In contrast, northern whitefish stocks have remained relatively static during the last two years.

The recent equalization of commercial operators' and commercial fishermens' quotas has effectively increased the quota for southern Lake Winnipeg by at least 600,000 lbs. This implies that fishing pressure will be increased even further. To afford at least some protection for the immature portions of southern walleye and sauger stocks, it is imperative that the minimum legal commercial mesh size in southern Lake Winnipeg be increased to at least 3.75 inches. It is highly apparent that a unit of effort on southern Lake Winnipeg is not maximizing economic returns to fishermen as it did in previous years. A fall fishery dependent on immature 2, 3 and 4 year old walleyes is not a self-sustaining system.

To attempt a refinement of management strategies, an analysis of the passage of cohort biomasses through the fishery is currently in progress.

The experimental fishing program in 1981 should be carried out in the same manner as the 1980 program.

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APPENDIX A
SPECIES COMPOSITION

Table A1. Species composition determined with experimental gillnet gangs.

Area	Gang no.	Number of fish														
		tullibee	burbot	sucker	pike	catfish	perch	drum	mooneye	goldeye	white bass	rock bass	carp			
South basin	1	19	9	5	1	1	3	33	0	0	0	0	0			
	2	3	0	0	0	0	0	19	0	0	0	0	0			
	3	3	4	36	1	4	4	111	0	0	1	0	0			
	4	3	4	7	2	1	12	42	0	0	1	0	0			
	5	15	5	16	6	0	4	93	0	0	0	0	0			
	6	15	4	13	4	0	0	104	0	0	0	0	0			
	7	55	18	3	2	1	2	96	0	0	0	0	0			
	8	24	18	1	0	0	0	67	0	0	0	0	0			
	9	2	0	0	0	1	0	11	0	0	0	0	1			
	10	36	5	5	0	3	0	238	0	0	0	0	0			
	11	1	1	1	2	2	1	11	1	0	0	0	1			
	12	0	0	0	0	1	0	9	0	0	0	0	0			
	13	2	0	0	1	0	0	16	0	0	0	0	0			
	14	0	0	4	0	0	0	45	0	0	0	1	0			
	15	1	0	1	9	0	0	35	1	1	0	0	0			
	16	0	0	0	2	0	0	1	0	1	0	0	0			
	17	1	0	0	7	0	0	8	0	0	2	0	0			
	18	6	3	9	0	0	10	12	0	0	0	0	3	walleyes	saugers	whitefish
	Σ	186	71	101	37	14	36	951	2	2	3	1	5	375	458	7
	%	8.27	3.16	4.49	1.65	0.62	1.60	42.29	0.09	0.09	0.13	0.04	0.22	16.67	20.36	0.31
Channel	31	2	0	37	12	3	14	24	0	1	0	0	0			
	32	696	113	34	0	0	3	14	0	0	0	0	0			
	33	628	633	28	0	0	0	6	0	0	0	0	0			
	34	6	3	7	6	0	40	10	0	1	0	0	0	walleyes	saugers	whitefish
	Σ	1332	749	106	18	3	57	54	0	2	0	0	0	37	381	194
	%	45.41	25.54	3.61	0.61	0.10	1.94	1.84		0.07				1.26	12.99	6.61
North basin	19	134	10	14	0	0	2	1								
	20	23	0	14	2	0	1	2								
	21	72	42	16	1	0	0	0								
	22	85	19	32	0	0	0	0								
	23	31	34	9	0	0	3	0								
	24	0	6	12	49	0	2	0								
	25	17	11	28	3	0	1	0								
	26	16	0	1	0	0	1	1								
	27	10	6	2	0	0	0	0								
	28	328	0	64	3	0	54	0								
	29	89	1	23	10	0	9	1								
	30	58	10	169	0	0	28	0						walleyes	saugers	whitefish
	Σ	863	139	384	68	0	101	5						289	911	2091
	%	17.79	2.87	7.92	1.40		2.08	0.10						5.96	18.78	43.10

APPENDIX B
COMPARISON OF WALLEYE SCALE AGES AND OTOLITH AGES

Table B1. Scale ages and corresponding mean otolith ages of walleyes from Lake Winnipeg.

Scale age (years)	Mean otolith age ± 2 S.D. (years)	Number of fish
3	2.32 < 3.83 < 5.34	6
4	2.62 < 4.43 < 6.24	54
5	3.52 < 6.28 < 9.05	14
6	2.92 < 6.00 < 9.08	39
7	4.31 < 7.29 <10.27	14
8	5.16 < 8.16 <11.15	38
9	7.42 <11.67 <15.91	9
10	5.48 <14.50 <23.52	4
11	12.84 <18.00 <23.16	4
12	16	1
13	19	1
14	16	1